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POPULATION AND DEMOGRAPHY Report No. 1

Estimation of Recent Trends in Fertility and Mortality in the Republic of Korea

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Committee on Population and Demography
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Preface

The Committee on Population and Demography was established in April 1977 by the National Research Council, in response to a request by the Agency for International Development (AID) of the U.S. Department of State. It was widely felt by those concerned that the time was ripe for a detailed review of levels and recent trends of fertility and mortality in the developing world. Although most people in the demographic community agree that mortality has declined in almost all developing countries during the last 30 years, there is uncertainty about more recent changes in mortality in some countries, about current levels of fertility, and about the existence and extent of recent changes in fertility.

In 1963, a Panel on Population Problems of the Committee on Science and Public Policy of the National Academy of Sciences published a report entitled *The Growth of World Population*. The appointment of that panel and the publication of its report were expressions of the concern then felt by scientists, as well as by other informed persons in many countries, about the implications of population trends. At that time, the most consequential trend was the pronounced and long-continued acceleration in the rate of increase of the population of the world, and especially of the population of the poorer countries. It was estimated in 1963 that the annual rate of increase of the global population had reached 2 percent, a rate that, if continued, would cause the total to double every 35 years. The disproportionate contribution of low-income areas to that acceleration was caused by rapid declines in mortality combined with high fertility that

remained almost unchanged: the birth rate was nearly fixed or declined more modestly than the death rate.

Since the earlier report, however, the peak rate of growth in the world's population has apparently been passed. A dramatic decline in the birth rate in almost all the more developed countries has lowered their aggregate annual rate of increase to well below 1 percent, and the peak rate of increase has also apparently been passed in the less-developed parts of the world as a whole. A sharp decline in fertility in many low-income areas has more than offset the generally continued reduction in the death rate, although the rate of population increase remains high in almost all less-developed countries.

The causes of the reductions in fertility—whether they are the effect primarily of such general changes as lowered infant mortality, increasing education, urban rather than rural residence, and improving status of women or of such particular changes as spreading knowledge of and access to efficient methods of contraception or abortion—are strongly debated. There are also divergent views of the appropriate national and international policies on population in the face of these changing trends. The differences in opinion extend to different beliefs and assertions about what the population trends really are in many of the less-developed countries. Because births and deaths are recorded very incompletely in much of Africa, Asia, and Latin America, levels and trends of fertility and mortality must be estimated, and disagreement has arisen in some instances about the most reliable estimates of those levels and trends.

It was to examine these questions that the Committee on Population and Demography was established within the Assembly of Behavioral and Social Sciences of the National Research Council. It was funded for a period of three years by AID under Contract No. AID/pha-C-1161. The Committee has undertaken three major tasks:

1. To evaluate available evidence and prepare estimates of levels and trends of fertility and mortality in selected developing nations;
2. To improve the technologies for estimating fertility and mortality when only incomplete or inadequate data exist (including techniques of data collection);
3. To evaluate the factors determining the changes in birth rates in less-developed nations.

Given the magnitude of these tasks, the Committee decided to concentrate its initial efforts on the first two tasks; it initiated work on the third task in 1979.

The Committee approaches the first task through careful assessment, by

internal and external comparison, and through analysis, by application of the most reliable methods known, of all the data sources available. Each of the country studies therefore consists of the application of a range of methods to a number of data sets. Best estimates of levels and recent trends are then developed on the grounds of their consistency and plausibility and the robustness of the individual methods from which they were derived.

The Committee's second task, refinement of methodology, is seen as a by-product of achieving the first. The application of particular methods to many different data sets from different countries and referring to different time periods will inevitably provide valuable information about the practical functioning of the methods themselves. Particular data sets might also require the development of new methodology or the refinement of existing techniques.

The Committee set three criteria for identifying countries to study in detail: that the country have a population large enough to be important in a world view; that there be some uncertainty about levels and recent trends of fertility or mortality; and that sufficient demographic data be available to warrant a detailed study. After a country has been selected for detailed study, the usual procedure is to set up a panel or working group of experts, both nationals of the country and others knowledgeable about the demography and demographic statistics of the country. The role of these panels and working groups, which generally include at least one Committee member, is to carry out the comparisons and analyses required. A small staff assists the Committee, panels, and working groups in their work.

As of mid-1979, 106 population specialists around the world were members of one or more panels or working groups. This number includes 66 specialists from developing nations. The Committee, the Assembly, and the National Research Council are grateful for the unpaid time and effort these experts have been willing to give.

Each country being studied has a different mix of data sources and different problems with data errors. Therefore, there is no standard pattern for all the reports. However, each report includes a summary of the main findings regarding estimates of fertility and mortality, a description of the data sources available, and a presentation of the analyses that were carried out, classified by type of data analyzed; detailed methodological descriptions are included where necessary in appendixes.

In some of the reports the estimates of fertility and mortality are presented as ranges. The use of a range is deliberate. It indicates that the panel and the Committee are confident that the range includes the true value, but have concluded that the evidence does not warrant selecting a

single figure as best. The range conveys an important aspect (uncertainty) of the estimation. Ideally, in constructing an average for several populations in each of which estimation is presented as a range, an aggregate range should be calculated (as the population-weighted average of the constituents). The user who selects a single figure from the middle of the range does so at the risk of misleading simplification.

This report is No. 1 in a series produced by the Committee. The report analyzes available data and provides estimates of the levels and recent trends of fertility and mortality in the Republic of Korea. It has been prepared by two Committee members, Ansley J. Coale and Lee-Jay Cho, assisted by Noreen Goldman of Princeton University.

This report built on the foundations of much prior analysis of Korean population statistics and profited from the help and advice of the professional and technical staff at the East-West Population Institute. The detailed age-specific fertility schedules for individual calendar years previously constructed by Cho and his colleagues form the basis, with some adjustment, of our principal estimates. The series of fertility surveys in Korea culminating in the 1974 Korean National Fertility Survey were useful, as was the extensive set of estimates prepared by T. H. Kwon.

Minja Kim Choe and Ruby Bussen of the technical staff at the Institute contributed many of the calculations underlying this report, calculations that combined their skill in programming and their knowledge of technical demography and Korean statistics. Chai Bin Park, research associate at the Institute, provided unpublished data from his files and helpful advice.

Special acknowledgment is owed to Griffith Feeney, research associate at the Institute, who generously made available to the project the worksheets of his own estimates of fertility and mortality in Korea, prepared by Feeney as a consultant to the Bureau of Statistics, Economic Planning Board, Republic of Korea. The worksheets included registered births and deaths by single years of age from 1971 to 1975, hand copied from the archives of the Bureau. They also included estimates of the completeness of registration of births and deaths constructed by methods only slightly different from those we employed, and with similar results. Feeney had in addition estimated by demographic analysis the completeness of coverage (by sex and five-year age intervals) in the censuses of 1970 and 1975. His estimates will be published elsewhere.

The Committee is grateful to all of the individuals and institutions for their time and the materials they provided to us for preparing this report.

ANSLEY J. COALE, *Chairman*
Committee on Population and Demography

Summary of Findings

This section presents a summary of the principal results of the estimation of fertility and mortality trends in the Republic of Korea. The numerical results are accompanied by a brief discussion of the validity and significance of the estimates; a technical description of how the estimates were constructed is presented in later sections.

The principal results regarding the trend in fertility in Korea from 1955 to 1975 show an increase in fertility during the late 1950s to a high point in 1960, a steep decline for 6 or 7 years, a temporary slackening of the rate of decline in the late 1960s, and a resumption of the steep decline in the first half of the 1970s (see Tables 1 and 2). Table 1 includes three standard measures of fertility: the crude birth rate or births per thousand population; the general fertility rate, or births per thousand women aged 15–49; and the total fertility rate, the number of children that would be born per woman reaching age 50 if women were subject to the age-specific fertility rates of the year in question. Table 2 shows the age-specific fertility schedules at the dates of the five censuses from 1955 to 1975.

The basis for the estimates is the so-called own-children procedure. It involves calculation of the number of births that must have occurred each year to account (after due allowance for mortality) for the number of young persons (i.e., those under age 21 in 1975 to estimate births since 1955) enumerated by age in the censuses of 1966, 1970, and 1975. Ages of childbearing used in calculating age-specific fertility schedules are derived from census information on the ages of the mothers of children living in the households at the time of the censuses. The estimates were calculated

TABLE 1 Corrected Numbers of Female Births, Numbers of Females 15-49, Crude Birth Rates (CBR), General Fertility Rates (GFR), and Total Fertility Rates (TFR), 1955-1975: Republic of Korea

Year	Female Births (in thousands)	Midyear Female Population 15-49 (in thousands)	CBR[a]	GFR[b]	TFR[c]
1955	413[d]	5,227	39.5	164	5.46[e]
1956	413	5,362	38.2	160	5.33[e]
1957	430	5,501	38.4	162	5.40
1958	484	5,629	41.9	178	5.94
1959	496	5,735	41.8	179	5.93
1960	512	5,834	42.1	182	5.98
1961	492	5,939	39.6	172	5.62
1962	486	6,072	38.1	166	5.41
1963	494	6,223	37.6	165	5.35
1964	459	6,368	34.0	150	4.86
1965	444	6,505	32.2	142	4.61
1966	451	6,629	31.9	141	4.59
1967	438	6,780	30.3	134	4.34
1968	459	6,957	31.2	137	4.42
1969	463	7,150	30.8	134	4.39
1970	458	7,386	29.8	129	4.27
1971	469[f]	7,626	29.8	128	4.26
1972	469[f]	7,858	29.3	124	4.18
1973	445[f]	8,118	27.3	114	3.86
1974	431[f]	8,407	25.9	107	3.62
1975	388[f]	8,710	22.8	92	3.14

[a]The crude birth rate is calculated as the general fertility rate times the quantity (midyear female population 15-49 ÷ midyear total population) taken from uncorrected census data.
[b]GFR = (2,075 × female births) ÷ female population 15-49.
[c]Calculation of TFRs is based on the following reported own-children schedules: 1957-1958 from Cho (1971), 1959-1970 from Cho (1974a), and 1971-1975 from unpublished data from the 1975 census.
[d]Average of births 1954-1956.
[e]TFRs for 1955 and 1956 estimated from trend in GFRs 1955-1957.
[f]Based on average of 1966 and 1970 undercounts in ages 0-4. The conspicuously low value of fertility for 1975 could be caused by a particularly serious undercount of children under 1 year of age in 1975 relative to earlier censuses.

after adjustment of the three censuses for relative understatement and overstatement of the number of persons at individual ages.

Because of the unusual accuracy of the reporting of age in the Korean censuses, the occurrence of a peak total fertility rate in 1960 and the subsequent large decline can be accepted as genuine. Specifically, the increase in fertility in the late 1950s is confirmed by the recorded differences in the number of children at the appropriate ages in 1966, 1970,

TABLE 2 Estimated Age-Specific Fertility Rates (per thousand women) for Census Years: Republic of Korea

Year	Age Group							Mean Age of Childbearing
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	
1955[a]	39	240	288	245	184	82	14	30.2
1960	35	249	323	273	204	96	16	30.5
1966	19	193	290	207	131	61	17	30.2
1970	13	174	298	207	111	43	8	29.8
1975	12	153	256	131	55	18	3	28.7

[a] The schedule for 1955 is based on the reported pattern of fertility for 1957 and the corrected TFR for 1955.
SOURCE: Age patterns of fertility are the reported own-children schedules for 1957-1975 (see footnote c of Table 1).

and 1975. Only an increase of fertility between 1956 and 1960 could account for the large number of children at age 6 relative to the number at age 10 in 1966, the large number at age 10 relative to the number at age 14 in 1970, and the large number at age 15 relative to the number at age 19 in 1975. The time sequence of aggregate fertility presented in Table 1 and the changing patterns of age-specific fertility rates presented in Table 2 are confirmed by evidence from independent sources, and they are also consistent with recorded changes of behavior within the Korean population.

The most precise corroboration of the principal estimates is an independent confirmation of the average level and the average age pattern of fertility during the five-year period from 1971 to 1975. This confirmation is provided by calculations based on registered births adjusted for incomplete registration. The average value of the total fertility rate, 1971–1975, in Table 1 is 3.81; the corresponding figure from corrected registered births is 3.80. The virtually identical average age-specific fertility schedules for 1971–1975 calculated from these independent sources are shown in Figure 1. The registration of births is wholly independent of the enumeration of young children in the 1975 census—the source of the estimates of fertility from 1971 to 1975 in Table 1. The adjustment for underregistration is derived from the number of children ever borne by women at each age as recorded in the 1970 and 1975 censuses, so that the correction for underregistration is also independent of the reported age distribution of young children.

Additional features of the estimates presented in Tables 1 and 2 find confirmation (although not so exact) from other independent evidence, namely the births reported in two large-scale sample surveys in which

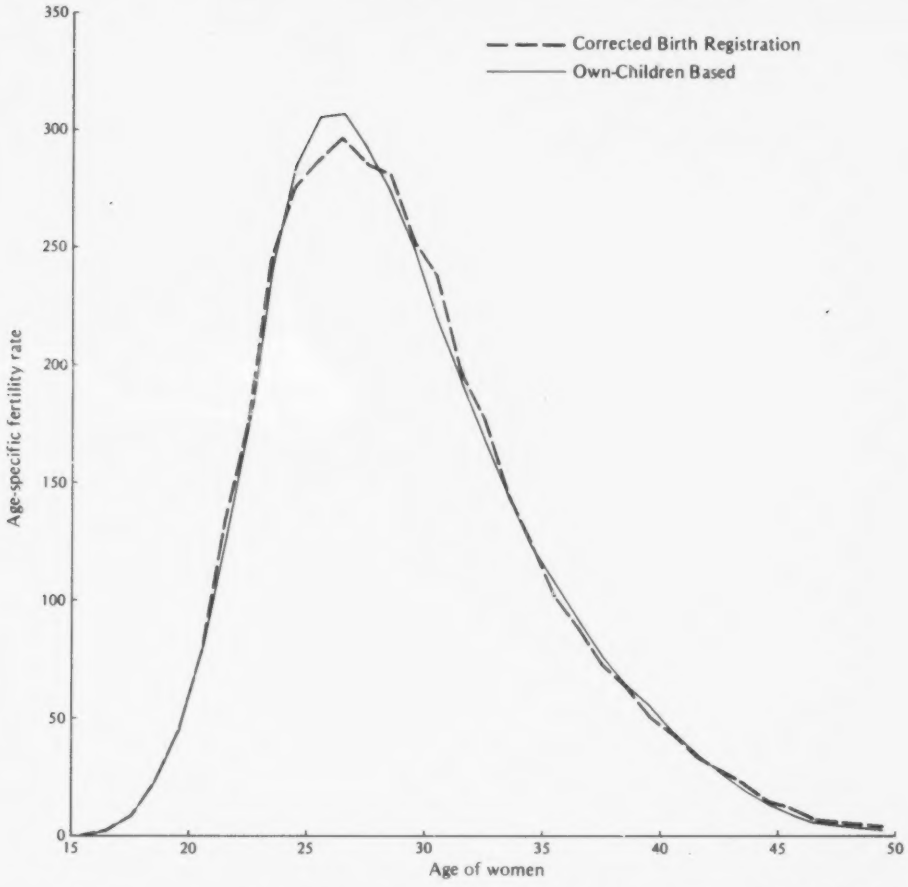


FIGURE 1 Age-specific fertility rates (per thousand women), 1971–1975, calculated from corrected birth registration and from own-children estimates: Republic of Korea.

respondents supplied detailed histories of their lifetime childbearing. The aggregate level of overall fertility in the two five-year time intervals prior to these surveys is closely, though not perfectly, consistent with the estimates presented in Table 1; the age pattern in each case is very close to that given in Table 2. The total fertility rate from each survey for the five years prior to the survey is 4 percent higher than our estimates. Age-specific fertility rates by five-year age groups from the surveys and from our estimates are compared in Figure 2.

The time sequence of total fertility rates from 1960 to 1974 presented in Table 1 is compared in Figure 3 with estimates derived from two sets of data in the Korean National Fertility Survey of 1974: own-children estimates from the household census of the surveyed population, and

FIGURE 2 Average age-specific fertility rates (per thousand women) for 1966–1970 and 1970–1974 derived from survey pregnancy histories and from adjusted own-children estimates: Republic of Korea.

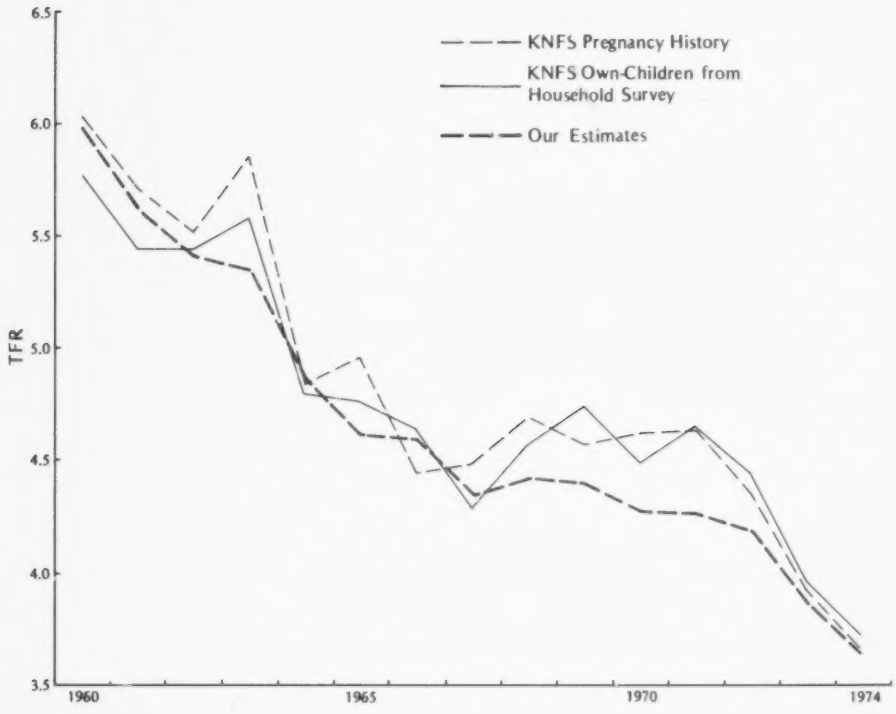


FIGURE 3 Estimated total fertility rates, 1960–1974: Republic of Korea.

NOTE: KNFS pregnancy history and own-children tabulation are based on unpublished tabulations in the Korean National Fertility Survey. Our estimates are adjusted census-based own-children estimates.

estimates obtained from the retrospective reports of previous births by individual women. The time patterns are similar, but differ in detail, especially from 1968 to 1972, when the survey-based estimates are higher. The source of this discrepancy is higher relative numbers of young children in the relevant birth cohorts recorded in the survey of 1974 than in the 1975 census (those aged 2–6 in 1974 and 3–7 in 1975). Because of problems associated with the limited size and possible bias in the sample employed in the survey, the census seems the more robust basis of estimates.

The weakest feature of the estimates in Table 1 is the sequence of rates by single years since 1970. The overall level appears correct because of the extraordinary agreement with corrected registered births. But in calculating fertility by single calendar years after 1970, the sole source of data was numbers of children under age 5 from the 1975 census—single-year

cohorts enumerated but once; therefore, it was necessary to adjust the recorded numbers of children at each age under 5 by the average adjustment found for the two preceding censuses. For example, it is possible that the sharp drop in the total fertility rate from 1974 to 1975—from 3.62 to 3.14—is a slight exaggeration; this would be true if the undercount of children under age 1 in 1975 was more pronounced than the average undercount in 1966 and 1970.

The decline in aggregate fertility after 1960 shown in Table 1, and the especially large reductions in age-specific fertility at ages under 25 and over 30 shown in Table 2, can be explained by two patterns of changing behavior among Koreans. The first change is increasing age at marriage, which caused a large reduction in fertility at the younger childbearing ages. The mean age at first marriage, as calculated from the proportion of women single by age recorded in the censuses, was as follows (Coale et al. 1979):

Periods	Mean Age at First Marriage for Women
1950-1955	20.5
1955-1960	21.7
1960-1966	23.0
1966-1970	23.3
1970-1975	23.7

The second behavior change is a rapid increase in contraception and induced abortion, which caused a large reduction in fertility among older married women. According to surveys taken in 1965 and 1974, the proportion of married women currently practicing contraception increased from 16 percent to 37 percent; from 1968 to 1974 the proportion reporting having had at least one abortion rose from 16 percent to 30 percent (Bureau of Statistics and Korean Institute for Family Planning 1977).

In addition to estimates of fertility, a purpose of our research is to develop estimates of recent levels and trends in mortality in the Republic of Korea. Indeed, since our procedure involved reverse projection to calculate the annual number of births, estimates of mortality were an intrinsic part of our fertility estimates. Our estimates show a rapid decline in mortality from 1955 to 1975. The following table shows the average female infant mortality rate for each intercensal period since 1955 and the female expectation of life at birth and at age 5 for these same periods: (For reasons explained below, estimation of male mortality above age 5 was more difficult and was not attempted except for 1971–1975, since estimates of male mortality were not required for our estimates of fertility.

We noted, however, a peculiar property of male mortality in Korea—particularly high death rates among older males.)

Period	Infant Mortality Rate	Expectation of Life	
		At Birth	At Age 5
1955-1960	0.056	58.9	57.9
1960-1966	0.053	60.4	60.0
1966-1970	0.041	64.5	63.2
1970-1975	0.033	67.2	65.1

The estimates of infant mortality rates are not precise; the conventional procedure of estimation from the proportion dead among children ever born as recorded in censuses leads in Korea to an apparent underestimation, and we have accepted the infant mortality rates that were obtained in the 1971 Survey of Fertility and Abortion. This survey produces estimates of infant mortality rates that are uniformly above those from the more conventional estimation procedure, but they show a parallel downward trend. The estimation of mortality at ages above early childhood is derived from the recorded survival of the population from one census to the next and could be biased for particular periods by variation from one census to the next in the overall completeness of coverage. However, the decline in infant mortality and the rise in expectation of life at birth are undeniable and substantial.

The rapid decline in mortality would have caused an acceleration in the rate of increase in the population had it not been offset by the even more rapid decline in fertility. In fact, however, the rate of increase in the population declined sharply, as shown in the following table of the population of Korea by sex in the five censuses since 1955 and the average intercensal rates of increase:

Date	Population at Census Dates (in thousands)		Intercensal Period	Intercensal Rate of Growth	
	Male	Female		Male	Female
1955	10,753	10,749	1955-1960	0.031	0.029
1960	12,544	12,445	1960-1966	0.026	0.025
1966	14,684	14,475	1966-1970	0.018	0.020
1970	15,780	15,656	1970-1975	0.020	0.019
1975	17,445	17,234			

Estimation of Recent Trends in Fertility and Mortality in the Republic of Korea

ESTIMATION OF FERTILITY, 1955–1975, BY ADJUSTMENT OF OWN-CHILDREN CALCULATIONS

ESTIMATION OF FERTILITY BY REVERSE PROJECTION

Measures of fertility for the years preceding a census can be estimated by projecting in reverse the number of persons at different ages. Thus, the crude birth rate t years before the census may be estimated by reverse projection to birth of the number of persons aged t at the census, combined with reverse projection of the whole population to determine the appropriate denominator for the birth rate t years before the census. A more refined measure—the general fertility rate t years before the census—can be estimated by reverse projection to birth of the number of persons now aged t, combined with reverse projection of the women in the census aged $15 + t$ to $50 + t$ to estimate the appropriate denominator.

The accuracy of an estimate of fertility for a particular year derived by reverse projection depends on how well the projection allows for the actual change in the populations that form the numerator and denominator of the measure estimated and on how accurately the census records the subgroups projected to form the numerator and denominator of the fertility measure. Since the birth rate and the general fertility rate are ratios, however, equal proportionate errors in counting or projecting the two groups that form the numerator and denominator (for example, a 5-percent undercount of both populations or a 2-percent overstatement of the proportion surviving in each group) would still allow an accurate

estimate of the birth rate or of the general fertility rate. But misstatement of age, transforming children from one age to another, or differences in omission rates by age would introduce spurious intertemporal variation in fertility estimates. For example, systematic overstatement of age such that the true number under 1 (or under 5) is understated produces the false appearance of declining birth rates and declining general fertility rates, as does differential omission of young children. In many populations, respondents do not know the age or date of birth of the children (or of the adults, for that matter) in the household. The age distribution recorded in the census of such a population is erratic and does not follow the true sequence of numbers of children by age; reverse projection consequently leads to an erratic sequence of estimated general fertility rates (or birth rates). Only when the age distribution is corrected, or can be closely approximated by adjustment of the reported numbers, does the estimated sequence of fertility rates resemble the true sequence. When an inaccurate age distribution is corrected, the time structure of estimated fertility is determined by the adjusted age distributions; if the corrections to the age distribution are imperfect, so is the validity of the estimated sequence.

Often there is no adequate basis for ascertaining the true age distribution, and reverse projection cannot then determine the true time variation in fertility before the census. If the adjustments are arbitrary, the estimated time structure is the artificial product of arbitrary procedures.

The own-children method is an elaborate form of reverse projection that yields much information in addition to the series of crude birth rates and general fertility rates that can be obtained from simple reverse projection. The additional information made possible by own-children procedures includes estimates of age-specific fertility rates. A particularly useful (age-distribution-free) aggregate measure of fertility—the total fertility rate or, alternatively, the gross reproduction rate—becomes calculable. Moreover, the fertility of subgroups of the population, defined, for example, by level of education, can be calculated by own-children techniques, but not by simple reverse projection. In short, own-children procedures, by identifying particular past births with particular women, introduce the opportunity for all kinds of microanalysis, whereas simple reverse projection is limited to the coarsest kind of macroanalysis.

The essence of the estimation by reverse projection of the general fertility rate x years before a census taken at time t is expressed in the equation:

$$\mathrm{GFR}\,(t-x) = \frac{C\,(x,t)\,(l_0/l_x)}{\int_{15+x}^{50+x} W(a,t)\,(l_{a-x}/l_a)\,da}. \qquad (1)$$

Children x years of age are projected in reverse to birth; women at ages from $15 + x$ to $50 + x$ are projected in reverse to determine the number aged 15 to 50 x years earlier.

OWN-CHILDREN ESTIMATES OF FERTILITY

The own-children technique requires a special tabulation that identifies individual children as the offspring of specified women on the basis of relationships within the household as recorded in the census. The essence of the own-children procedure is expressed in the equation[1]:

$$f(a-x, t-x) = \frac{C_a(x,t)\,(l_0/l_x)}{W(a,t)\,(l_{a-x}/l_a)}. \qquad (2)$$

Those children x years of age whose mothers are a years old are projected in reverse to birth to estimate how many births occurred x years ago to women then $a - x$ years old (including children at age x without an own mother, who are allocated to women at age a); the denominator is an estimate, by reverse projection, of the number of women at age $a - x$, x years before the census.

The capacity of own-children analysis to yield age-specific rates and fertility measures for women of particular characteristics does not free it from the effects of misreported age distributions in the census to which it is applied. The point can be put very simply: own-children estimates add nothing to the precision of the estimated series of general fertility rates that can be calculated by simple reverse projection.[2] Own-children estimates of aggregate fertility are just as erratic, when derived from censuses in which the ages of children are misstated or in which children at different ages are differentially omitted, as are estimates of aggregate fertility derived by simple reverse projection.

In short, own-children estimates of fertility are useful when the distribution of the population by single years of age is highly accurate or can be made highly accurate by slight adjustment.

OWN-CHILDREN ESTIMATION OF FERTILITY IN KOREA

Because of the accurate reporting of the distribution of the population by age in the Republic of Korea, the own-children technique is particularly applicable to Korea. The special tabulations required by the method were made from the censuses of 1966, 1970, and 1975. The estimates presented

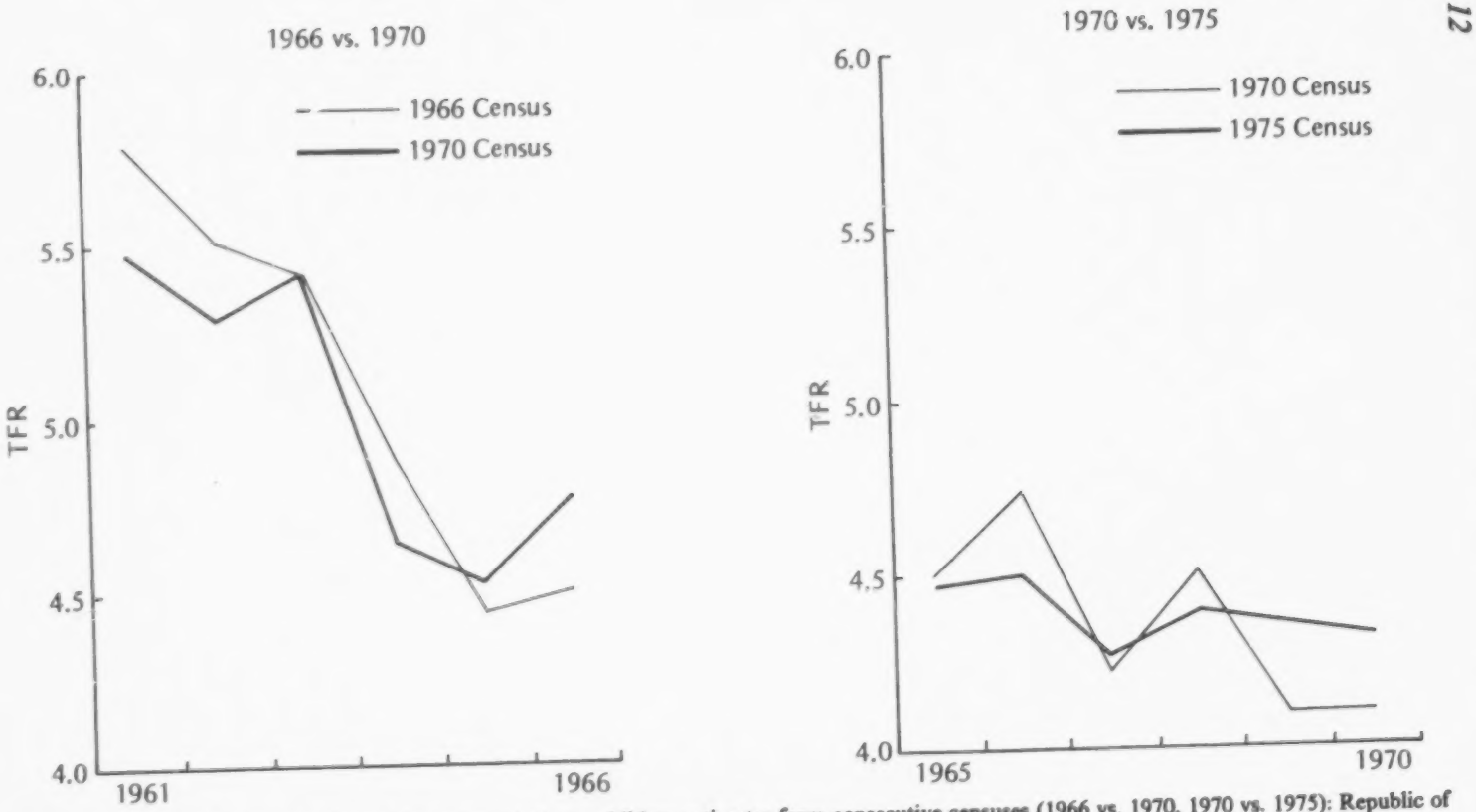


FIGURE 4 Total fertility rates based on uncorrected own-children estimates from consecutive censuses (1966 vs. 1970, 1970 vs. 1975): Republic of Korea.

SOURCES: TFRs based on 1966 census are taken from Cho (1971). TFRs based on 1970 census are taken from Cho (1974a) and unpublished data. TFRs based on 1975 census are taken from unpublished data.

here are based (after special corrections) on the own-children fertility schedules for 1957 to 1975 calculated by Lee-Jay Cho and his colleagues: fertility schedules based on the 1966 census (Cho 1971); revised estimates including those derived from the 1970 census (Cho 1974a); and calculations made at the East-West Population Institute of own-children estimates from the 1975 census (not yet published). The unusual accuracy of age reporting in Korean censuses is not sufficient to yield perfectly consistent own-children estimates when derived from data from different censuses. The age patterns of the fertility schedules are quite similar, but for particular years, estimated measures of aggregate fertility derived from different censuses are not in perfect agreement (Figure 4).

ADJUSTMENTS OF THE REPORTED AGE DISTRIBUTION AND OF OWN-CHILDREN FERTILITY ESTIMATES

We estimated more nearly correct age distributions of the female population by single years of age for 1966, 1970, and 1975 in three steps:

1. Special understatement and overstatement of numbers at different individual ages in 1970 were corrected. (The special defects in 1970 are associated with improper correction for the use of the lunar calendar in reporting age.)
2. The reported distributions by five-year age intervals of the female population in the three censuses were corrected by a technique of demographic analysis that predicates similar patterns of distorted age structure in consecutive censuses.
3. The proportion of each five-year cohort falling within single-year cohorts was calculated separately for males and females in the three censuses. An estimate of individual cohort size (within the five-year cohort) was derived from these six observations for each cohort.

By reverse projection of the corrected female age distributions, female births (and total births, on the assumption of a fixed sex ratio) were estimated for individual years from 1955 to 1970; corrected female populations at the childbearing ages were also calculated for the same years. The ratio of estimated births to estimated female population provided our estimates of annual general fertility rates. The age pattern of the fertility schedules previously constructed at the East-West Population Institute was accepted as correct; the entire schedule for each year was adjusted by scalar multiplication so that the age-specific rates when applied to the corrected female population yielded the estimated overall number of births. The age-specific schedules thus adjusted to the proper

level were cumulated to provide our estimates of annual total fertility rates shown in Table 1. Fertility schedules for selected years appear in Table 2. A detailed description of the methods of estimation in this section is given in Appendix A.

ESTIMATION OF FERTILITY, 1971–1975, FROM REGISTERED BIRTHS ADJUSTED FOR UNDERREGISTRATION

Births in Korea are registered by year of birth and age of mother. The resulting data are little utilized and not widely publicized because of two deficiencies. First, there is often a substantial delay in registration: the births occurring in a given calendar year are registered during the next several years. Second, even after allowance for delayed registration, it is clear that the number of registered births falls short of the actual total.

ESTIMATION OF COMPLETENESS OF REGISTRATION IN COMPARISON WITH DATA ON PARITY FROM CENSUSES

Births registered prior to December 31, 1976, for the calendar years 1971–1975 are shown in Table 3, by age of mother in single years. The accuracy of age reporting in Korea, and the tabulation of average number of children ever born (average parity) by single years of age in 1970 and 1975, makes it possible to estimate the fraction of the actual number of births that were registered in the years between the censuses. The principle is simple: the increase in average parity for women in a given cohort (for example those 15 in 1970 and 20 in 1975) is equal to the total number of births experienced by the cohort between the two censuses, divided by the mean size of the cohort. The registered number of births at the appropriate ages in the intercensal years divided by the mean size of the cohort is the *registered cohort intercensal birth rate*; the difference in average parity recorded in 1970 and 1975 can be called the *census cohort birth rate*. On the assumption that parity is correctly reported, the ratio of the registered rate to the census rate is a measure of the completeness of birth registration. In detail, the requisite calculations are rather complicated; they are described in Appendix C.

Table 4 and Figure 5 show the ratio of average registered births per cohort to the increase in average parity from 1970 to 1975. The sequence of ratios for individual cohorts fluctuates moderately around a constant value until it rises to more than one for the oldest cohort. The rising ratio for older cohorts is undoubtedly the result of understatement of parity at older ages in 1975; this understatement is discussed in detail below.

The median ratio of increase in parity estimated from registered births

TABLE 3 Births Occurring during 1971-1975 and Registered by the End of 1976, by Year of Birth and Age of Mother at Birth: Republic of Korea

	Year of Birth					
Age	1971	1972	1973	1974	1975	Total
14 (or less)	243	298	440	928	1,363	3,272
15	170	146	121	87	20	544
16	1,497	1,214	954	603	195	4,463
17	4,092	3,812	3,125	1,940	797	13,766
18	8,538	7,817	7,884	5,678	2,628	32,545
19	14,916	13,738	13,384	12,473	6,296	60,807
20	22,815	23,491	22,442	19,821	13,089	101,658
21	35,045	28,866	33,291	29,575	24,674	151,451
22	47,087	43,270	38,175	40,091	23,194	191,817
23	60,988	54,537	55,104	50,014	40,378	261,021
24	67,978	64,393	62,035	56,953	35,627	286,986
25	58,045	67,708	67,944	58,103	40,740	292,540
26	65,065	55,255	67,128	61,996	40,465	289,909
27	63,616	56,759	53,149	58,145	37,769	269,438
28	67,849	54,866	51,151	43,636	35,550	253,052
29	64,580	54,420	46,542	37,797	23,027	226,366
30	54,876	54,850	47,313	37,243	21,011	215,293
31	46,688	40,429	43,479	32,286	17,043	179,925
32	40,503	36,517	34,350	33,631	17,548	162,549
33	33,551	30,303	29,627	23,538	15,412	132,511
34	28,916	24,992	24,507	20,846	11,348	110,609
35	24,630	20,768	19,344	15,157	8,806	88,705
36	21,591	18,046	16,350	12,571	6,823	75,381
37	16,377	14,853	13,879	10,189	5,085	60,385
38	13,519	12,007	12,090	8,598	4,603	50,817
39	10,841	9,085	8,902	6,902	3,456	39,186
40	9,220	7,652	7,592	5,115	2,812	32,391
41	7,388	5,507	5,423	3,645	1,866	23,829
42	5,147	4,819	4,172	2,838	1,522	18,498
43	4,080	3,224	3,597	2,107	1,338	14,346
44	2,860	2,112	2,143	1,413	646	9,174
45	1,994	1,643	1,615	947	535	6,734
46	1,339	968	856	545	263	3,971
47	943	739	567	383	210	2,842
48	976	597	499	222	134	2,428
49	671	565	358	192	103	1,889
50 (and over)	1,074	842	484	476	166	3,042

SOURCE: Feeney (1977).

TABLE 4 Comparison of Average Number of Registered Births per Cohort (1971-1975) with Intercensal Cohort Birth Rate (1970 vs. 1975): Republic of Korea

Age in 1975	Registered[a] Cohort Birth Rate (1)	Intercensal[b] Cohort Birth Rate (2)	Ratio[c] (1) ÷ (2)
20	50	69	0.73
21	115	136	0.85
22	243	254	0.96
23	298	421	0.71
24	563	658	0.85
25	746	906	0.82
26	948	1,136	0.83
27	1,055	1,343	0.79
28	1,142	1,424	0.80
29	1,193	1,455	0.82
30	1,078	1,456	0.74
31	1,132	1,372	0.82
32	1,043	1,235	0.84
33	1,008	1,140	0.88
34	894	1,020	0.88
35	720	874	0.82
36	701	744	0.94
37	538	624	0.86
38	396	491	0.81
39	386	395	0.98
40	334	356	0.94
41	292	221	1.32

[a]1975 registered births increased by 39 percent for delayed registration.
[b]Intercensal birth rates corrected for one-half year of age.
[c]Median ratio equals 0.835.
SOURCES: Registered cohort birth rate calculated from Table 2 above, Economic Planning Board, Korea (1973: Vol. II, Table 1) and (1976: Table 1).
Intercensal cohort birth rate calculated from Economic Planning Board, Korea (1973: Vol. II, Table 1) and (1976: Table 3).

to the recorded increase in the censuses for cohorts no more than 35 years of age in 1975 may be taken as an estimate of the completeness of registration of births (after the births in 1975 have been given a preliminary correction of 1.39—see Appendix C). The median figure of 0.835 can then be used as a divisor of the number of registered births to provide estimates of the true number of births in the intercensal period (again after a special adjustment is made for the 1975 registered births). The adjusted aggregate number of births, 1971–1975, by single years of age have been divided by the estimated average number of person-years at each

FIGURE 5 Ratio of registered cohort birth rate (1971–1975) to intercensal cohort birth rate (1970–1975): Republic of Korea.

individual age (from the adjusted population) to construct the age-specific fertility schedule for the quinquennium between the two censuses. In Figure 1, this schedule of age-specific fertility rates derived from registered births is compared with a schedule of age-specific rates obtained by our corrections to own-children estimates calculated from the 1975 census. The two schedules in Figure 1, derived by wholly independent procedures, are in extraordinarily close agreement.

UNDERSTATEMENT OF PARITY IN 1975 AT AGES ABOVE 38

In Figure 5 the ratio of the registered birth rate to the census birth rate (for 1971–1975) is plotted by age of women in 1975. The ratio turns up sharply above age 38; it is not shown above age 41 because the reported increase in parity for older women becomes negative. The increase in parity implied by registered births adjusted for underregistration can be added to the parity reported by women in each cohort in 1970 to construct a figure for 1975, on the assumption that the 1970 reports were correct. This construction is compared with the parity reported in 1975 in Figure 6. Note that the two sets of numbers are virtually identical until just below age 40; the divergence then increases rapidly. At ages in the middle to late

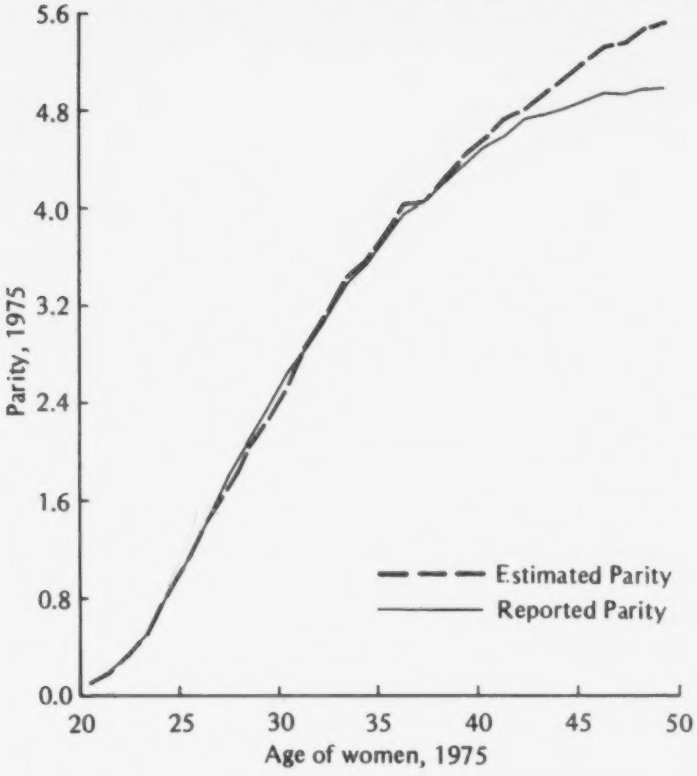


FIGURE 6 Reported parity in 1975 census vs. estimated parity (sum of parity in 1970 census and intercensal increase in parity from adjusted registered births 1971–1975): Republic of Korea.

forties even the constructed figure is too small, because parity was doubtlessly understated in 1970 by women then five years younger.

The initiation of a consequential understatement of parity only at ages older than 35 supports the hypothesis that the principal reason for increasing understatement of the number of children ever born with increasing age is the omission of children who have left the parental home, rather than forgetting. Respondents may misunderstand the intent of a question concerning the number of children they have ever borne and conclude that offspring who have matured and left home should be omitted. In Korea in 1975, the late thirties are ages at which women would be mothers of offspring old enough to be considered no longer children.

ESTIMATION OF FERTILITY FROM SPECIAL SURVEYS

Detailed fertility histories were obtained from large samples of ever-married women in the 1971 Fertility-Abortion Survey, conducted by the Korean Institute for Family Planning (Moon et al. 1973), and in the Korean National Fertility Survey (KNFS), conducted jointly in 1974 by the National Bureau of Statistics and the Korean Institute of Family Planning in cooperation with the World Fertility Survey. From these fertility histories, we have computed average age-specific fertility schedules for the five-year time intervals preceding each survey, in the belief that the effects of sampling variance, event misplacement, and omission would be minimized by aggregating the births that occurred during five years before the survey.

Detailed pregnancy records were obtained from approximately 6,300 and 5,400 ever-married women of reproductive age in the 1971 Fertility-Abortion Survey and the 1974 Korean National Fertility Survey, respectively. These women were identified from samples of approximately 6,800 and 21,000 households, respectively, in the two surveys. The calculation of age-specific fertility rates for periods preceding the survey dates was based on data from both the fertility histories and the household survey as follows:

1. Numerators consisted of births recorded in the pregnancy histories, classified by calendar year and by age of mother at the time of the birth.
2. Denominators consisted of person-years of exposure of women, classified by calendar year and by age of women. The age distribution of ever-married women at the time of the survey was inflated by the proportion of women in the household survey who were ever married at the corresponding age to obtain an age distribution for all women. By reverse counting, person-years were obtained for calendar years prior to the survey date.

For the KNFS, age-specific fertility rates for the year 1974 were increased by a factor of 1.23 to account for a full year's exposure because the survey was conducted between September and December. Also, since the individual survey in the KNFS restricted interviews to women under age 50, total fertility rates for years prior to 1974 were obtained from age-specific fertility rates derived partly from the detailed pregnancy history (at younger ages) and partly from the own-children tabulation of the household survey (for the latter portion of the reproductive age span).

The schedules derived from the surveys are compared with our adjusted own-children schedules in Figure 2. The total fertility rates for the time

periods 1966–1970 and 1970–1974 are 4.57 and 4.22 as calculated from the surveys and 4.40 and 4.04 as calculated by adjustment of own-children estimates. Although our estimates are about 4 percent lower for both periods, the two sources show the same 8 percent proportionate decline and virtually the same age pattern at each date.

A more detailed comparison of the time pattern of fertility change was obtained by computing total fertility rates from 1960 to 1974 from data collected in the 1974 KNFS. Age-specific fertility schedules for each calendar year were derived from this survey in two essentially independent ways. A fertility schedule at each date was obtained by applying the own-children method to information about age distribution and household composition obtained in the Household Survey conducted as part of the KNFS. Another set of schedules (again, one for each year from 1960 to 1974) was derived from the detailed fertility history obtained from the sample of ever-married women interviewed in the survey.

The annual total fertility rates derived by these two procedures are compared in Figure 3 with our adjustment of own-children estimates based on the censuses. Although the estimates differ for some individual years (for example, 1963 and 1965), and our estimates are lower than the other two from 1968 to 1972, the time patterns are generally similar: a steep decline from 1960 to 1966 or 1967, little change from 1967 to 1972, and then a resumption of a decline. The difference in the estimates for 1968–1972 is caused by relatively larger numbers at ages 2–6 in the 1974 survey than at ages 3–7 in the 1975 census. Similarly, the difference in 1963 is the result of a large cohort reported at age 11 that is not matched by an equally large cohort at age 7 in 1970 or at age 12 in 1975. Evidently the distribution of children by age recorded in the Household Survey was consistent with the dates of birth reported in the fertility histories, as can be seen in the two curves in Figure 3 derived from the KNFS.

The household sample was large, but clustered: it included 103,000 persons in 316 enumeration districts, systematically sampled from the universe of some 70,000 districts. The age and sex distribution in the Household Survey is somewhat more erratic than in the censuses, as is evident, for example, in more erratic sex ratios by five-year age intervals (see Table 1 in Bureau of Statistics and Korea Institute for Family Planning 1977). The sex ratios at ages 30–60 in the Household Survey are unaccountably different from the ratios for the same ages, or for the same cohorts, in the censuses. Hence, much of the deviation at particular years shown in Figure 3 is the result of minor flaws in recording the population by age and births by year in the survey.

ESTIMATION OF MORTALITY

The life tables that are used in arriving at adjusted own-children fertility estimates are composites: a model life table is selected to match estimates of infant mortality derived from surveys, which provides mortality up to age 5, and another model life table is selected by forward projection to provide estimates of mortality above age five (see Appendix A).

INFANT MORTALITY ESTIMATED FROM RETROSPECTIVE DATA IN FERTILITY SURVEYS

The use of data on infant mortality from the 1971 Fertility-Abortion Survey and the Korean National Fertility Survey requires further comment. Since the Korean censuses of 1966, 1970, and 1975 incorporated questions about children ever born and children surviving, child mortality can be calculated by the Brass method or the Sullivan or Trussell modifications of the Brass procedures (Brass and Coale 1968; Sullivan 1972; Trussell 1975). These techniques have proved very useful; in only a few instances do they fail to provide robust indications of the recent levels of infant and child mortality. The estimates of infant and child mortality in Korea by these techniques, however, appear to be too low; that is, the implied infant mortality rate in the 1970s of less than 20 per thousand is too low to be readily accepted.

Employing an extension of child-survival techniques, Griffith Feeney has calculated a sequence of estimated infant mortality rates extending back to the 1950s using data on children ever born and children surviving from the censuses of 1966, 1970, and 1975. Infant mortality rates from the surveys of 1971 and 1974 (Kim 1976; Bureau of Statistics and Korean Institute for Family Planning 1977) are derived from annual births and annual deaths under age 1 as reported in the retrospective fertility histories. In Figure 7 the moving average (five-year average except for the last point, which is a three-year average) of the infant mortality rates based on the surveys is compared with estimates for selected points prior to each census calculated by Feeney from census data on child survival. The estimates based on child survival are almost always lower, although the bias usually found in survey reports is understatement of infant mortality. Moreover, the child-survival estimates are implausibly low (infant mortality rates at or below 20 per thousand in the 1970s); at the level of adult mortality estimated from forward projection, model life tables show infant mortality rates of over 50 per thousand. A response bias against reporting dead children or a minor processing error could be the source of

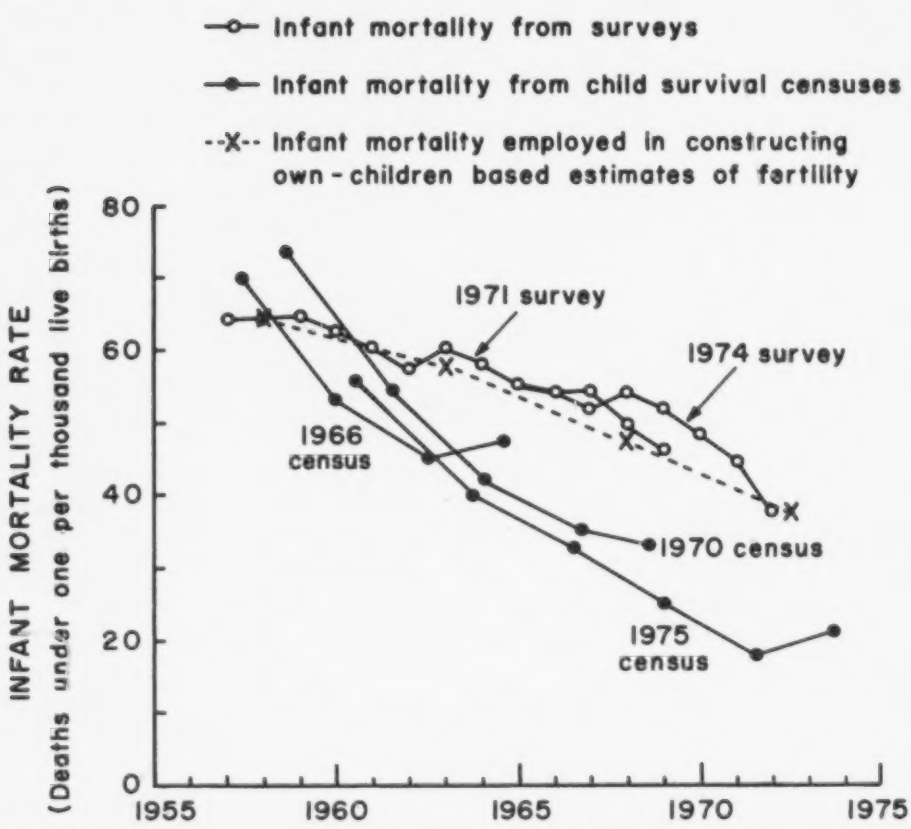


FIGURE 7 Infant mortality rates (deaths under 1 year of age per thousand live births) at various dates, 1957–1973, from surveys and censuses: Republic of Korea.

SOURCES: Survey data from Bureau of Statistics and Korean Institute for Family Planning (1977) and N. I. Kim (1976); child survival estimates from Cho and Feeney (1976).

NOTE: Survey rates (1971 and 1974) are five-year moving averages of annual infant mortality rates (except for the last data points for each survey, which are three-year moving averages).

understatement of the proportion dead among children ever born. Had lower infant mortality rates been accepted, the fertility estimates would have been lower by 2–4 percent.

MORTALITY ABOVE AGE 5 ESTIMATED BY FORWARD PROJECTION

Certain features of the selection of a model life table from age 5 to the end of life by forward projection also require comment. Forward projection provides a series of different estimates of the level of mortality. Specifically, a particular level of mortality is implied when the earlier population over age 10 is projected to match the later population over 15; quite a different level may be implied when the earlier population over 50 is projected to match the later population over 55. The levels of mortality will be about the same only if age misreporting is not extensive, if the censuses are of approximately equal completeness of coverage, and if the pattern of mortality in the model life tables is matched by the pattern of mortality in the population in question.

In Table A-1 (see Appendix A), the different levels of mortality (West model tables; Coale and Demeny 1966) determined by forward projection are shown for each intercensal period, for males and females. Mortality levels are specified in two ways: the level that yields the survival rate of each cohort from one census to the next, and the level that projects the entire population at ages x and over to match the later population at ages $x + n$ and over. In Korea, for each sex the individual cohort survival rates imply a very erratic sequence of mortality levels—at some ages even surpassing the highest, or falling below the lowest, survival rates in any model life table—because of different relative overstatement or understatement of cohort size in the two censuses. The levels determined by projection and cumulation are less variable, but are affected at the younger ages by special undercounts that occur at ages from about 15 to 30 in the different censuses. Above age 25 or 30, however, the forward projections are less affected by such census defects.

For females, the variation in mortality level in the West life tables selected by forward projection from age 25 to age 60 is confined to a narrow range for all intercensal periods, and to a very narrow range for the two most recent pairs of censuses. Apparently, recent Korean adult female mortality is quite consistent with the West family of model tables.

For males, no such consistency exists in the West levels of mortality estimated by forward projection. The fluctuations of estimated level for the childhood ages is even greater than for females, and above age 25 the sole consistency in pattern is a sort of systematic inconsistency, namely large declines in life table level (to schedules of higher mortality) as age increases. Apparently, recent Korean adult male mortality is not consistent with the West family of model life tables.

There are two possible interpretations of the declining levels shown in Table A-1: either the number of males is progressively more understated

with increasing age in each of the Korean censuses, or male mortality at older ages has been persistently high in relation to expectations based on mortality among females (or among younger males) and the general relations expressed in the West model tables. To see whether the mortality rates themselves are unusually high for older males, we analyzed death rates derived from registered deaths.

MORTALITY ABOVE AGE 5, 1971–1975, ESTIMATED FROM REGISTERED DEATHS ADJUSTED FOR UNDERREGISTRATION

The registration of deaths in Korea is analogous to the registration of births. Records of registered deaths are maintained, classified by age and sex, but the number of events registered is known to be incomplete. A simple modification of the forward projection technique was applied to the deaths registered from 1971 to 1975 (Tables 5 and 6) to estimate the completeness of registration: the number of registered deaths in each age interval during the five years was divided by the estimated number of person-years lived in each interval—5 times the average of the number of persons at those ages in the censuses of 1970 and 1975. (The numbers at 15–30 were increased by 5 percent and the numbers at 30–35 by 2 percent as a rough allowance for the most conspicuous undercounts.) The result is a mortality schedule that would be correct if deaths were fully registered. Alternative schedules are fabricated by multiplying this schedule by constants greater than 1.0 (allowing, in effect, for an increasing underregistration of deaths); each mortality schedule is converted into a life table and employed for forward projection from 1970 to 1975.

The succession of multipliers required to produce a life table that provides the proper population in 1975 when applied to the population over age x in 1970 is shown in Table 7. For both males and females there is little variation in the sequence. The median value is 1.26 for males and 1.45 for females, implying that 79 percent of male deaths and 69 percent of female deaths are registered. When registered deaths are multiplied by these median adjustments, the cumulated projected population matches the recorded 1975 population with an error of less than one percent at all ages up to 60.

Life tables for which mortality above age 5 is taken from registered deaths adjusted for underregistration instead of West model tables are given in Table 8. The sequence of West levels of mortality corresponding to the corrected age-specific death rates are shown in Figure 8. The female death rates conform to essentially the same level of West mortality from age groups 5–9 to 60–64; male mortality is at about the same West level as

TABLE 5 Male Deaths Occurring during 1971-1975 and Registered by the End of 1976, by Year of Death and Age at Death: Republic of Korea

Age Group	Year of Death					
	1971	1972	1973	1974	1975	Total
Total	108,487	94,871	124,845	112,702	99,965	540,870
0–4	7,826	5,962	6,559	6,168	4,707	31,422
5–9	4,255	3,047	4,549	4,240	3,697	19,788
10–14	3,439	2,597	3,531	3,217	2,697	15,481
15–19	4,429	3,972	5,192	4,764	4,029	22,386
20–24	3,833	3,578	4,275	4,136	3,779	19,601
25–29	3,248	2,814	3,404	3,103	2,737	15,306
30–34	3,323	3,202	3,835	3,585	3,123	17,068
35–39	3,883	3,570	4,122	4,002	3,520	19,097
40–44	4,677	4,268	5,003	5,021	5,101	24,070
45–49	6,735	5,877	6,543	6,151	5,172	30,478
50–54	8,308	7,613	9,700	8,990	8,388	42,999
55–59	9,934	8,887	11,251	10,216	8,585	48,873
60–64	10,850	10,108	12,969	11,881	10,597	56,405
65–69	9,413	8,668	12,571	11,687	10,102	52,441
70–74	9,642	8,170	10,930	7,771	8,713	45,226
75–79	6,450	5,530	8,935	7,858	6,073	34,846
80–84	4,953	4,258	6,284	5,354	4,377	25,226
85+	3,289	2,750	5,192	4,558	4,368	20,157

SOURCE: Feeney (1977).

female mortality under age 40, but is at sharply decreasing levels (higher mortality) at higher ages.

The consistency of these life tables calculated from corrected registered deaths with survival from 1970 to 1975 shows that Korean male mortality does indeed deviate from West model tables; the death rates for older males are much higher (relative to female death rates and to male mortality at younger ages) than in the model tables. The non-conformity of male mortality to the West tables implies that forward projection does not select (for males) a life table that fits well at any age; we have therefore based all our fertility estimates on the adjusted female age distributions.

TABLE 6 Female Deaths Occurring during 1971-1975 and Registered by the End of 1976, by Year of Death and Age at Death: Republic of Korea

Age Group	Year of Death					Total
	1971	1972	1973	1974	1975	
Total	76,212	64,401	87,342	77,589	68,385	373,929
0-4	7,269	5,495	5,949	5,566	4,254	28,533
5-9	3,355	2,483	3,783	3,641	3,119	16,381
10-14	2,601	1,970	2,867	2,589	2,114	12,141
15-19	2,799	2,320	3,254	2,973	2,877	14,223
20-24	2,923	2,533	3,202	2,823	2,803	14,284
25-29	2,862	2,290	3,005	2,577	2,269	13,003
30-34	2,625	2,377	2,881	2,705	2,370	12,958
35-39	2,774	2,367	3,002	2,622	2,330	13,095
40-44	2,873	2,669	3,175	2,957	2,761	14,435
45-49	3,285	2,850	3,479	3,344	3,048	16,006
50-54	3,627	3,249	4,287	4,035	3,717	18,915
55-59	4,381	3,806	4,898	4,353	3,809	21,247
60-64	5,080	4,573	6,180	5,583	5,114	26,530
65-69	5,665	4,877	6,958	6,326	5,499	29,325
70-74	7,084	5,992	7,705	5,284	5,758	31,823
75-79	6,102	5,143	7,823	7,092	5,243	31,403
80-84	5,868	5,111	7,207	6,339	5,030	29,555
85+	5,039	4,296	7,687	6,780	6,270	30,072

SOURCE: Feeney (1977).

TABLE 7 Multiplying Factors for Registered Deaths (1971-1975) Derived from Forward Projection, Males and Females: Republic of Korea

Cumulated Ages in 1975	Male Factor	Female Factor
10+	1.25	1.51
15+	1.22	1.50
20+	1.13	1.45
25+	1.20	1.47
30+	1.18	1.57
35+	1.25	1.42
40+	1.28	1.45
45+	1.26	1.43
50+	1.25	1.48
55+	1.27	1.48
60+	1.26	1.44
65+	1.19	1.44
70+	1.15	1.44
Median Multiplying Factor	1.26	1.45
Completeness of Death Registration	79%	69%

TABLE 8 Life Tables (over Age 5) [illegible]-1975, Constructed from Corrected Death Registration Data, Males and F[illegible]les: Republic of Korea

MALES e_5 = 57.2

Age	1,000 $q(x)$	$l(x)$	$L(x)$	West Level Implied by $q(x)$
5	10.60	100,000	497,080	17.6
10	8.43	98,940	492,700	17.3
15	14.55	98,106	487,100	16.6
20	16.30	96,678	479,610	18.2
25	15.43	95,102	471,990	18.9
30	18.68	93,635	463,980	18.5
35	23.35	91,885	454,280	18.4
40	37.69	89,740	440,580	17.0
45	58.25	86,358	419,720	15.4
50	94.93	81,328	388,110	12.9
55	134.94	73,608	344,200	11.8
60	202.63	63,675	287,410	10.3
65	277.35	50,772	220,070	9.9
70	380.86	36,690	149,920	9.6
75	503.08	22,717	85,013	10.3
80+	1,000.00	11,288	35,880	–

FEMALES e_5 = 63.9

Age	1,000 $q(x)$	$l(x)$	$L(x)$	West Level Implied by $q(x)$
5	10.35	100,000	497,020	17.1
10	8.17	98,915	492,630	17.2
15	11.20	98,107	487,900	17.6
20	14.44	97,008	481,680	17.7
25	15.36	95,607	474,510	18.2
30	17.03	94,138	466,840	18.4
35	18.55	92,535	458,550	18.7
40	24.45	90,818	448,760	18.5
45	32.42	88,598	436,100	18.4
50	46.81	85,726	419,000	18.2
55	63.34	81,713	396,150	18.7
60	96.63	76,538	364,940	18.7
65	137.79	69,142	322,840	19.9
70	207.56	59,615	268,380	21.0
75	303.37	47,241	200,380	22.2
80+	1,000.00	32,910	169,850	–

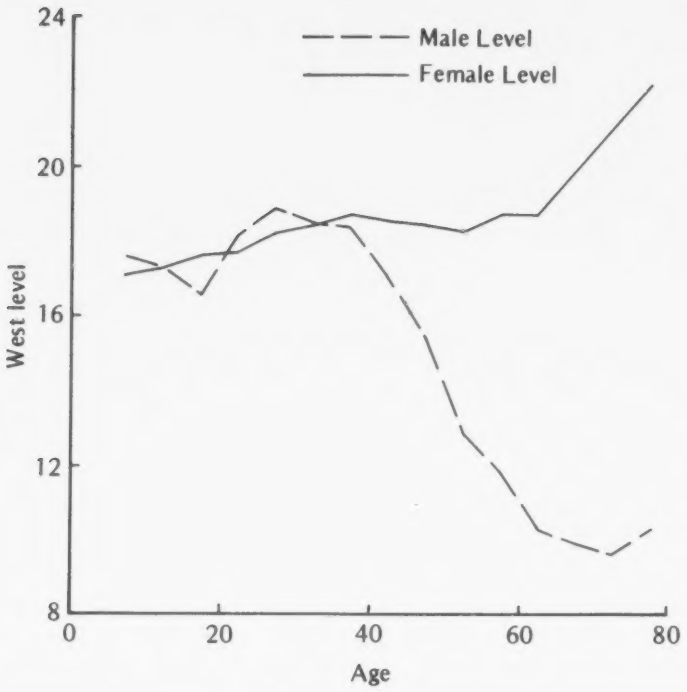


FIGURE 8 West levels of mortality calculated from age-specific death rates, for five-year age groups, based on corrected death registration data, males and females, 1971–1975: Republic of Korea.

Appendixes

A ADJUSTMENT OF OWN-CHILDREN FERTILITY ESTIMATES BY CORRECTION OF FEMALE AGE DISTRIBUTIONS IN KOREAN CENSUSES

ACCURATE AGE REPORTING

The own-children method by which our estimates were constructed is especially useful when ages are correctly reported. Censuses in Korea record the age distribution of the population with unusual accuracy because Koreans, even those without education, have very precise knowledge of the date of their birth. This knowledge derives from the importance in Korea of a belief in astrology that leads every individual to know the "animal year" of birth, and also, in most instances, the precise date of birth according to the Chinese lunar calendar. If the census in Korea includes a question on date of birth (rather than on age) and if age is then calculated by subtracting the date of birth from the date of the census, the determination of age is more accurate than in censuses taken in many highly educated Western populations. These aspects of Korean culture made it possible for the Japanese colonial government before World War II to record the age distribution of the population in a series of censuses from 1925 to 1944 with unusual accuracy. When the censuses were resumed in the Republic of Korea after World War II, the same

precision in age determination could have been achieved; as explained below, however, that precision was not always attained. The first census with fully published tabulations after the war was in 1955, followed by censuses in 1960, 1966, 1970, and 1975.[3] In all but the 1960 census, age was ascertained by including a question on date of birth and calculating age by subtraction of this date from the date of the census. In 1960 there was an ill-advised change to a question about age at last birthday, a modification that appears to have led generally to reporting of age by the Chinese system of reckoning, according to which an infant is 1 year old at birth and becomes one year older on each New Year. This unfortunate change in procedure makes the age distribution of the population in 1960 imprecise and hard to relate to data in the other censuses.

CORRECTING THE REPORTED AGE DISTRIBUTION

Greater precision in estimating fertility—whether by simple reverse projection to estimate aggregate measures of fertility or by the own-children technique to estimate fertility schedules—can be obtained from the recorded age distribution of a closed population if errors in the distribution can be detected and corrected. The possibility of detecting errors in the Korean censuses is enhanced by the existence of five counts of the population (in 1955, 1960, 1966, 1970, and 1975) in 20 years. Experience with other populations has shown that basically unchanging procedures of enumeration create similar patterns of overstatement and understatement of numbers at different ages in consecutive censuses (Coale 1955; Coale and Zelnik 1963; Demeny and Shorter 1968; Coale and Rives 1973). The similarity of pattern is revealed, and the extent of overstatement and understatement estimated, by tracing the enumeration of the same cohorts in the different censuses. Changes in cohort size from one census to the next are approximated by survival rates in appropriately devised life tables.

Construction of Life Tables for Projecting the Population for Each Intercensal Period

The life tables used in the detection and correction of errors in the published age distribution are composite tables, one for each intercensal interval. Mortality up to age 5 was estimated from data on infant mortality obtained from the 1971 Korean Fertility-Abortion Survey, in which detailed fertility histories (including the date of death of each child who

died) were recorded (Kim 1976). Values of 1_1, 1_2, . . . , 1_5, and of ${}_1L_0$, ${}_1L_1$, . . . , ${}_1L_4$, were taken from West model life tables chosen to match the average infant mortality during each intercensal interval (Coale and Demeny 1966). Mortality above age 5 was determined by forward projection, a technique by which a model life table is chosen that provides that projection of the population recorded in the earlier census that best matches the population recorded in the later census. If the censuses are five years apart, a model life table can be found such that the total number in the projected population over age 5 matches the total recorded number aged 5 and over at the later date. Another model table can then be independently chosen so that it projects a population over age 10 to match the recorded population; similarly over age 15, etc. If the two age distributions are accurately recorded, if migration is negligible, and if the age pattern of mortality in the model life tables is mirrored in the mortality of the population, the sequence of model tables selected will scarcely differ in mortality level. (See United Nations 1967, and National Research Council 1980.)

For 1960–1966 and 1966–1970, forward projection was by six-year and four-year age intervals, respectively, utilizing West model life tables in single years of age constructed by Ruby Bussen at the East-West Population Institute. The final level of mortality selected was the median of the first 10 levels. For example, for 1955–1960, the median level was chosen from the life tables that produce the corrected total projection in 1960 at 5^+, 10^+, . . . , 50^+ from the 1955 population.

Except for variation associated with apparent omission of young children and of young adult women, the sequence of mortality levels as calculated by forward projection is confined within rather narrow limits for females, but not for males (Table A-1). This approximate conformity of female but not male mortality to the West pattern is confirmed by the age-specific mortality schedule for 1971–1975 constructed from registered deaths adjusted for underregistration (see Table 8). The constructed intercensal life tables for females (a composite of forward projection with estimated infant mortality) are shown in Table A-2.

Because male survival was poorly matched by West model life tables, the calculation of adjusted populations by single years of age at the census dates was restricted to the female population. Since the principal purpose of the adjustments is to improve the estimation of fertility, corrected female age distributions are sufficient. When projected back to birth, the female cohorts provide estimates of annual female births; the number of male births is readily estimated on the assumption of a fixed sex ratio at birth.

TABLE A-1 Expectation of Life at Birth (West Model Tables) in Intercensal Life Tables Calculated by Census Survival Rates and Forward Projection, Males and Females: Republic of Korea

Table A-1a: 1955-1960

Age at Earlier Census	MALE e_0		FEMALE e_0	
	Proportion of Cohort Surviving	Forward Projection	Proportion of Cohort Surviving	Forward Projection
5	63.9	44.6	48.7	49.8
10	18.0	43.2	20.0	49.9
15	18.0	52.1	28.9	57.6
20	73.9	64.2	77.5	62.5
25	73.9	56.3	62.1	58.9
30	73.9	46.6	77.5	58.5
35	67.4	42.0	53.7	54.6
40	55.7	38.6	59.0	54.8
45	26.3	35.5	38.8	54.0
50	45.4	39.1	77.5	57.8
55	37.7	37.3	65.2	52.7
60	34.1	37.0	48.8	48.7
65	35.5	39.2	44.8	48.6
70	45.7	44.0	57.3	53.0

Table A-1b: 1960-1966

Age at Earlier Census	MALE e_0		FEMALE e_0	
	Proportion of Cohort Surviving	Forward Projection	Proportion of Cohort Surviving	Forward Projection
6	31.1	49.2	52.9	59.1
12	42.1	51.7	38.1	59.8
18	39.8	53.0	77.5	63.0
24	73.9	55.5	60.6	57.5
30	73.9	46.9	71.9	56.9
36	49.3	42.2	47.1	54.1
42	48.7	40.5	59.4	55.8
48	42.5	38.2	66.5	55.0
54	37.1	36.2	53.7	51.6
60	34.5	35.8	49.3	50.7
66	37.7	37.0	51.2	52.0

Table A-1c: 1966-1970

Age at Earlier Census	MALE e_0		FEMALE e_0	
	Proportion of Cohort Surviving	Forward Projection	Proportion of Cohort Surviving	Forward Projection
4	53.4	39.2	51.0	54.1
8	30.7	37.9	52.3	54.4
12	18.0	38.5	20.0	54.6
16	27.9	45.6	33.2	61.5
20	18.0	47.6	77.5	64.7
24	73.9	57.5	55.7	63.9
28	73.9	54.0	77.5	64.9
32	67.4	50.5	63.8	63.4
36	59.3	48.3	61.3	63.3
40	55.4	46.8	61.2	63.6
44	54.4	45.4	71.5	63.9
48	46.9	43.8	55.4	62.9
52	50.3	43.1	68.9	64.0
56	37.0	41.4	50.3	63.2
60	44.3	43.1	67.1	66.3
64	36.0	42.6	51.8	66.1
68	44.2	47.5	67.7	71.3
72	38.9	50.7	59.4	72.9

Table A-1d: 1970-1975[a]

Age at Earlier Census	MALE e_0		FEMALE e_0	
	Proportion of Cohort Surviving	Forward Projection	Proportion of Cohort Surviving	Forward Projection
5	67.7	50.7	77.4	60.8
10	18.0	49.3	20.0	59.7
15	73.7	57.4	59.1	67.3
20	54.1	56.0	77.5	68.2
25	73.9	56.3	60.0	66.2
30	73.9	51.3	76.9	67.0
35	60.6	46.9	68.0	65.7
40	52.0	44.3	69.7	65.4
45	51.4	42.9	61.9	64.7
50	44.0	40.8	70.5	65.2
55	37.1	39.7	51.8	64.1
60	39.0	41.0	65.5	67.9
65	40.2	42.4	65.0	68.9
70	40.5	44.4	66.0	70.7

[a]1975 age distributions are based on the 5-percent sample.

TABLE A-2 Intercensal Female Life Tables, Constructed by Splicing Mortality above Age 5 from Forward Projection with Mortality up to Age 5 from Reported Infant Mortality: Republic of Korea

Table A-2a: FEMALES 1955-1960, $e_O = 58.9$

Age	1,000 $q(x)$	$l(x)$	$L(x)$
0	56.40	100,000	95,599
1	23.35	94,360	371,817
5	15.43	92,158	457,234
10	11.95	90,735	450,968
15	17.09	89,651	444,426
20	22.31	88,119	435,680
25	25.48	86,153	425,276
30	28.95	83,958	413,711
35	32.89	81,527	400,929
40	37.72	78,845	386,791
45	45.29	75,872	370,764
50	61.34	72,435	351,066
55	83.31	67,991	325,797
60	123.72	62,328	292,358
65	179.82	54,616	248,527
70	270.42	44,795	193,690
75	393.57	32,682	131,251
80	1,000.00	19,819	96,828

Table A-2b: FEMALES 1960-1966, $e_O = 60.4$

Age	1,000 $q(x)$	$l(x)$	$L(x)$
0	52.57	100,000	95,838
1	20.77	94,743	373,963
5	13.55	92,777	460,744
10	10.52	91,520	455,194
15	15.15	90,558	449,356
20	19.87	89,185	441,493
25	22.80	87,412	432,080
30	26.02	85,419	421,541
35	29.83	83,196	409,780
40	34.66	80,716	396,584
45	42.28	77,918	381,353
50	57.71	74,623	362,351
55	79.04	70,317	337,691
60	117.94	64,759	304,704
65	173.23	57,122	260,872
70	262.61	47,227	205,129
75	385.35	34,825	140,575
80	1,000.00	21,405	106,836

Table A-2c: FEMALES 1966-1970, $e_O = 64.5$

Age	1,000 $q(x)$	$l(x)$	$L(x)$
0	41.40	100,000	96,583
1	13.38	95,860	380,195
5	8.91	94,578	470,784
10	6.95	93,736	467,051
15	10.33	93,085	463,018
20	13.79	92,123	457,439
25	16.04	90,853	450,619
30	18.56	89,396	442,828
35	21.90	87,736	433,878
40	26.55	85,815	423,379
45	34.17	83,536	410,546
50	47.77	80,682	393,776
55	67.26	76,828	371,222
60	101.88	71,661	340,050
65	154.72	64,360	296,904
70	240.50	54,402	239,302
75	361.83	41,319	169,218
80	1,000.00	26,368	140,272

Table A-2d: FEMALES 1970-1975,[a] $e_O = 67.2$

Age	1,000 $q(x)$	$l(x)$	$L(x)$
0	32.91	100,000	97,194
1	8.75	96,709	384,775
5	6.35	95,863	477,796
10	4.96	95,255	475,092
15	7.67	94,782	472,094
20	10.43	94,055	467,826
25	12.28	93,075	462,518
30	14.35	91,933	456,363
35	17.35	90,613	449,135
40	21.80	89,041	440,350
45	29.30	87,100	429,117
50	41.74	84,548	413,914
55	60.04	81,018	392,932
60	91.96	76,155	363,264
65	143.13	69,151	321,012
70	226.50	59,254	262,715
75	346.79	45,832	189,426
80	1,000.00	29,938	166,228

[a]Female 1975 age distribution is based on the 5-percent sample.

The Search for a Uniform Pattern of Understatement and Overstatement of Numbers by Age

If successive censuses were affected by similar patterns of exaggeration or understatement of numbers, the patterns should be visible in a comparison of what may be called survival ratios—the ratio of a census survival rate (the number of persons in a cohort recorded in a later census divided by the number recorded in an earlier census) to a life table survival rate (the corresponding fraction in the stationary population). This survival ratio can be expressed as

$$\frac{{}_nP_{a+n}(t+n)/{}_nP_a(t)}{{}_nL_{a+n}/{}_nL_a}. \qquad \text{(A-1)}$$

If a series of censuses with a constant intercensal interval were subject to similar errors, a plot of the survival ratios for each pair of censuses would exhibit more or less congruent fluctuations around 1.0.

There are two complications that impede the simple detection of the pattern of age misstatement in the Korean censuses. The more serious complication is the use in 1960 of a question on current age rather than date of birth; the less serious is the irregularity in intercensal intervals caused by the scheduling of a census in 1966 instead of 1965, which would have maintained five-year spacing. An attempt has been made to convert the ages reported in 1960 to Western ages by the following rule: the number at age x (last birthday) equals 11/12 the number listed at age x + 1 plus 1/12 the number listed at x + 2. This expedient for converting ages reported by the Chinese method of reckoning is an improvement on the ages as listed, but it is clearly not successful in reconstructing the age distribution into what would have been obtained by asking date of birth. The single-year survival ratios for 1955–1960 and 1960–1966 are erratic in ways that clearly show the different (and much larger) misreporting in 1960. The large and idiosyncratic undercounts and overcounts in 1960 are confirmed in our final estimates (see Figure A-12).

Because of the different basis for the determination of age in 1960, the search for a recurrent pattern of misstatement was confined to the censuses of 1966, 1970, and 1975 (the last available in the form of a 5-percent sample tabulation). The survival ratios for 1966–1970 and 1970–1975 are surprisingly variable and have a puzzling lack of similarity from one pair of censuses to the next (Figure A-1). Recall that if every cohort had been enumerated each time with the same completeness, all of the ratios would be very close to 1.0. The ratios oscillate irregularly around 1.0 above age

25, but are more than 1.0 at the two youngest ages, less than 1.0 in the early teens, and more than 1.0 around age 20. The most puzzling feature is the large amplitude and irregular ups and downs over the full span of ages, often quite different in detail for 1966–1970 and 1970–1975. The failure of the bumps and hollows to coincide was at first thought to be the result of the different duration of the intercensal intervals: for example, the cohort aged 15 in 1966 would be 19 in 1970, but a cohort aged 15 in 1970 would be 20 in 1975. Even after allowance for this difference, however, no simple hypothesis of heaping or avoidance at particular ages explains the differences in the two sets of ratios.

The Effect of the Chinese Calendar on Age Misreporting

In puzzling over this irregular pattern, Lee-Jay Cho speculated that some of the respondents had reported the Chinese year of birth rather than the Western year. According to the prescribed procedures, the date of birth was to be converted to the Western calendar before age was calculated. This conversion was necessary to prevent the recording of artificially large cohorts in some years and artificially small cohorts in others. The normal Chinese year consists of 12 lunar months, containing some 354 days. The calendar is kept in phase with the evolution of solar years by the insertion at irregular intervals of a Chinese leap year containing 13 lunar months. If seasonality of births is not quantitatively important, Chinese leap years contain 13/12 as many births as non-leap years, or 8.33 percent more. The prescribed conversion to a Western calendar avoids the creation of cohorts artificially enlarged or diminished (except for the trivial effect of one extra day in Western leap years). Retention of the Chinese calendar instead of conversion to the Western calendar would not explain the peculiarities in the sequence of survival ratios, however, since a cohort born in a leap year would be too large each time it was counted.

The hypothesis that the irregular survival ratios were somehow the result of imperfect conversion from the Chinese calendar was too tantalizing to abandon. It was recalled that there was hearsay evidence that the 1970 census had been less meticulously conducted in some respects than the censuses of 1966 and 1975. It was assumed, as a working hypothesis, that conversion of date of birth to the Western calendar had been neglected, or incompletely applied, in 1970, but not in 1966 or 1975. According to this hypothesis, leap-year cohorts would be inflated, and non-leap-year cohorts diminished, in 1970, but not in the other two years. The result would be high survival ratios for leap-year cohorts in 1966–1970 and low survival ratios for such cohorts in 1970–1975.

In Figure A-1, triangles appear above the survival ratios of leap-year

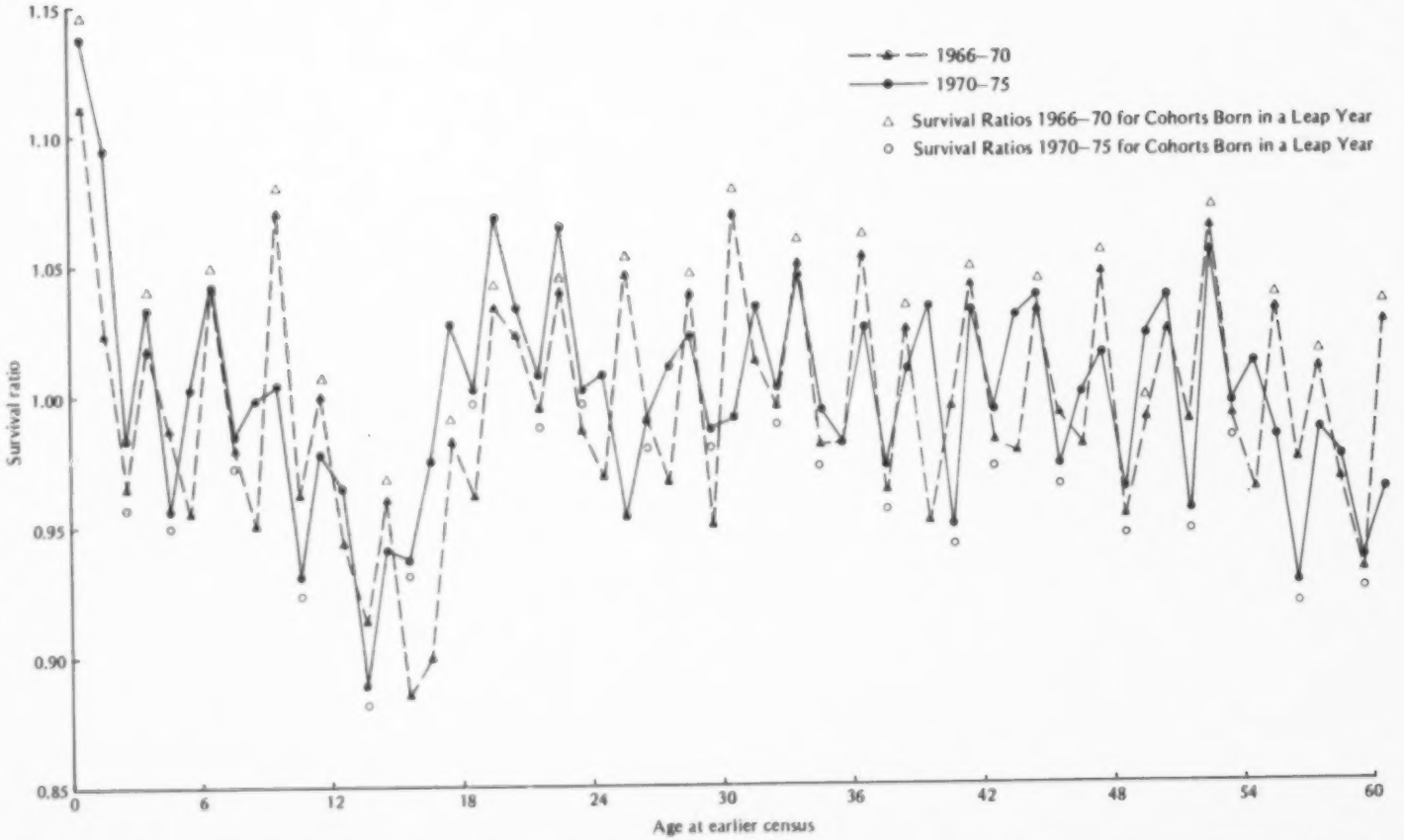


FIGURE A-1 Survival ratios (ratio of census survival rates to life table survival rates), females, 1966–1970 and 1970–1975: Republic of Korea.

cohorts in 1966–1970, and circles appear below the survival ratios of leap-year cohorts in 1970–1975. With one exception (age 49), triangles correspond to high points in the survival ratios for 1966–1970, and with only two exceptions, the circles correspond to dips in the survival ratios for 1970–1975. The missing dips (at ages 26 and 34) are concealed by still greater dips at ages 25 and 35. As will be shown below, there was a tendency in 1975 (and in 1966) to understate numbers of persons at ages above 20 divisible by 5, and a slight opposite tendency in 1970. The resultant dips in survival ratios have nothing to do with leap years. (See Appendix B for a comparison of the 5-percent sample with the complete enumeration of the 1975 female age distribution with respect to the survival ratios.)

The coincidence of peaks and troughs in Figure A-1 with the predicted locus of high and low ratios leaves no room for doubting that conversion to the Western calendar was less complete in 1970 than in the other censuses. Adjustment factors to normalize the number of persons in 1970 were calculated as follows: the survival ratio from 1966 to 1970 of each leap-year cohort was divided by the mean value of the survival ratios for the two adjacent cohorts to form an estimate of the excess size of leap-year cohorts. (Since leap years never occur consecutively, the adjacent cohorts are always non-leap-year cohorts.) The excess size of female leap-year cohorts so calculated is shown in Figure A-2.

The median value of excess size for female cohorts was 1.062; the corresponding median for males was 1.058. Since leap-year cohorts exceed non-leap-year cohorts by 8.33 percent, the excess numbers just calculated would have averaged 1.0833 had all dates of birth in 1970, and none in 1966, been given on the Chinese calendar. If the 1970 census is accepted as the culprit, the median of 1.06 implies that 6.0/8.33 or 72 percent of dates of birth were reported in this way in 1970. A Chinese leap year is 5.1 percent longer than a Western year; other Chinese years, consisting of 12 lunar months, are 97.0 percent as long as a Western year. Thus, the number of persons at any age corresponding to a Chinese leap year in 1970 was divided by $1 + (.72)(.051)$ and the number born in intervening years divided by $1 - (.72)(.03)$. The 1970 age distribution adjusted for the effect of the Chinese calendar is presumably subject to defects one might expect to be shared by the adjacent censuses. In Figure A-3 survival ratios for 1966–1970 and 1970–1975 are shown after the 1970 female age distribution has been adjusted for the effects of years of nonconstant length in the Chinese calendar. The two sequences are much less irregular than in Figure A-1 (before such adjustment); the low points for 1970–1975 at 20, 25, 30, 35, and 40 are now clearly visible. Further search for overstatement

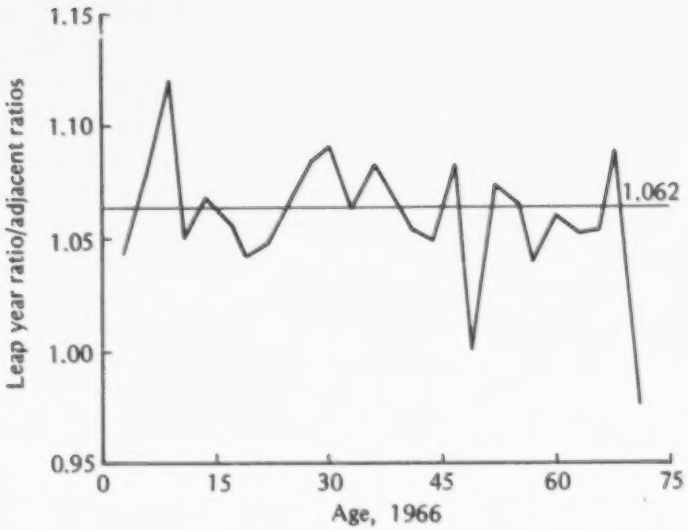


FIGURE A-2 Survival ratios, 1966–1970, of female leap-year cohorts divided by the mean survival ratio of adjacent cohorts: Republic of Korea.

and understatement of numbers uses the 1970 data adjusted in this manner.[4]

These adjustments may not have removed completely the effect of the Chinese calendar on the reported size of cohorts. The corrections applied to data from the 1970 census ensure allowance only for the conspicuous excess resulting from the use of the Chinese calendar in that census; there is no correction for whatever slight tendency there may have been for reporting year of birth by that calendar in 1966 and 1975. However, we have examined the median size of leap-year cohorts relative to the median size of their neighbors (see Table A-3) and find no systematic remaining excess.

Estimation of Relative Overstatement or Understatement of Numbers in Five-Year Age Intervals in 1966, 1970, and 1975

We now return to a search for similarities in the pattern of errors in the reporting of the female age distribution in consecutive censuses. It is evident in Figure A-3 that there must have been differences in patterns of overstated or understated numbers at individual ages among the three censuses since 1966. It was therefore decided to break up the estimation of the correct age distributions into two steps: first, to estimate relative

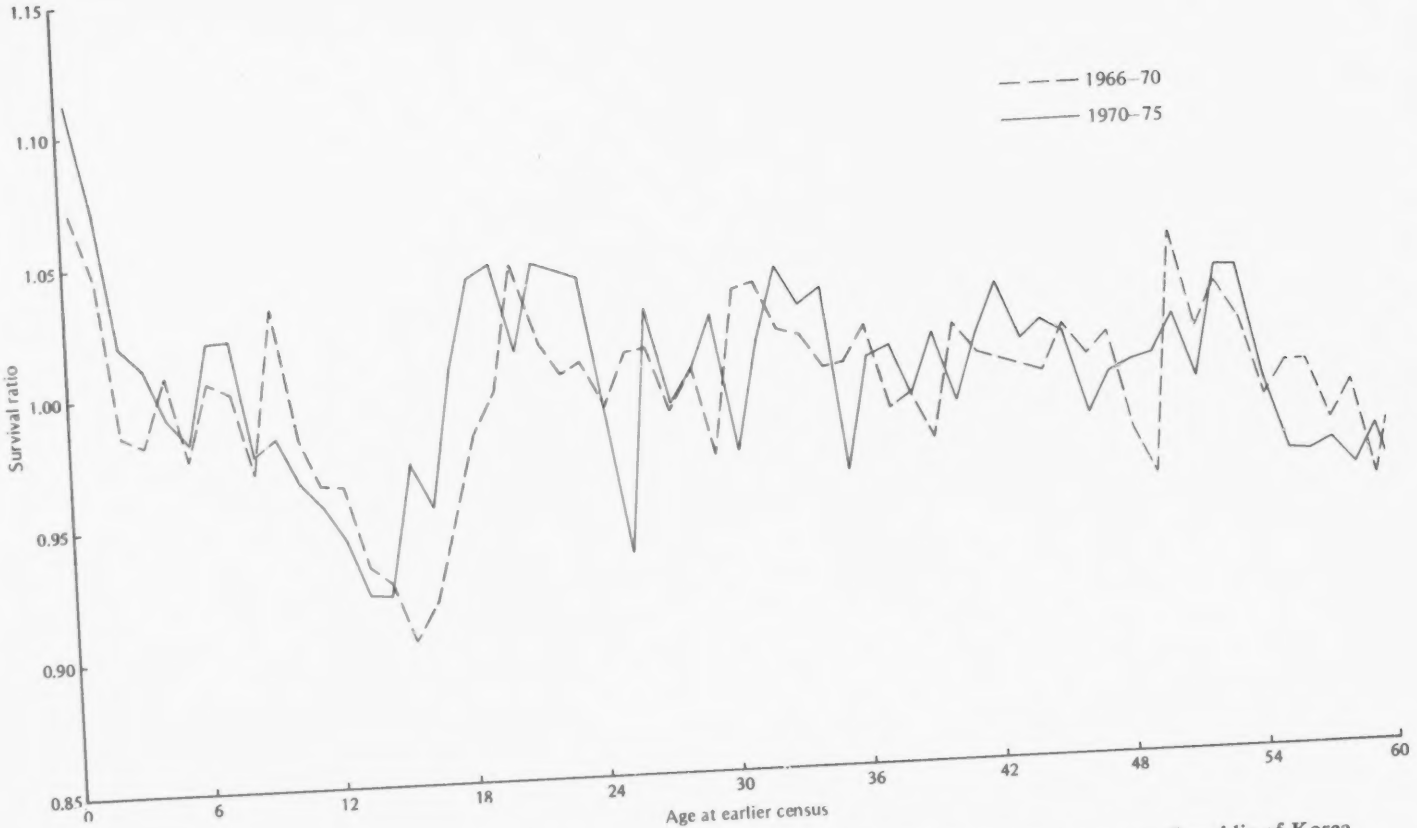


FIGURE A-3 Survival ratios, females, 1966–1970 and 1970–1975, with numbers in 1970 adjusted for leap years: Republic of Korea.

TABLE A-3 Single-Year Age Distribution within Five-Year Age Groups, by Cohort, 1966, 1970, and 1975: Republic of Korea

	1966			1970			1975[a]				
	Percent of Five-Year Age Groups			Percent of Five-Year Age Groups			Percent of Five-Year Age Groups		Age in	Median Percent	
Age	Male	Female	Age	Male	Female	Age	Male	Female	1970[b]	Male	Female[c]
1	18.4	18.4	5	19.1	19.2	10	18.9	18.9	5	18.9	
2	19.3	19.4	6	19.1	19.2	11	19.4	19.6	6	19.4	
3	20.9	20.7	7	20.5	20.4	12	21.0	20.9	7	20.8	
4	20.4	20.4	8	20.7	20.6	13	20.4	20.2	8	20.4	
5	21.0	21.1	9	20.6	20.6	14	20.3	20.4	9	20.6	
6	21.8	21.9	10	22.1	22.1	15	22.6	22.6	10	22.1	
7	21.2	21.2	11	21.4	21.2	16	21.6	21.6	11	21.3	
8	21.0	21.0	12	20.4	20.4	17	20.9	20.4	12	20.7	
9	18.2	18.1	13	18.7	18.7	18	18.3	18.3	13	18.3	
10	17.8	17.8	14	17.4	17.6	19	16.5	17.1	14	17.5	
11	24.9	24.8	15	25.7	25.5	20	24.0	24.8	15	24.8	
12	20.9	20.9	16	21.7	21.4	21	21.7	20.4	16	21.2	
13	18.5	18.5	17	18.5	18.3	22	18.7	18.4	17	18.5	
14	19.8	19.7	18	19.2	19.4	23	20.6	20.1	18	19.7	
15	16.0	16.2	19	15.0	15.5	24	15.0	16.2	19	15.8	
16	21.3	21.4	20	19.6	20.2	25	19.9	19.9	20	20.1	
17	20.7	20.6	21	20.0	20.0	26	20.1	20.4	21	20.2	
18	20.9	20.5	22	21.8	20.7	27	20.4	21.0	22	20.8	
19	20.2	20.3	23	21.0	20.8	28	21.5	21.0	23	20.9	
20	17.0	17.1	24	17.7	18.3	29	18.0	17.6	24	17.7	
21	20.0	18.7	25	18.7	18.9	30	18.2	17.7	25	18.7	
22	20.6	18.9	26	18.2	18.9	31	19.7	19.4	26	19.2	
23	20.8	19.3	27	19.5	19.4	32	19.1	19.3	27	19.3	
24	19.9	22.0	28	22.3	21.6	33	21.8	21.8	28	21.8	
25	18.7	21.1	29	21.3	21.2	34	21.2	21.8	29	21.2	
26	20.2	20.4	30	20.6	20.6	35	19.6	19.8	30	20.3	
27	20.5	20.9	31	20.5	20.7	36	20.5	20.6	31	20.5	
28	20.0	19.7	32	20.1	19.7	37	20.9	20.2	32	20.1	
29	20.3	20.3	33	19.5	19.7	38	19.6	19.8	33	19.7	
30	19.0	18.7	34	19.2	19.3	39	19.5	19.6	34	19.3	
31	22.7	21.8	35	23.1	22.3	40	22.7	21.6	35	22.7	21.8
32	21.7	20.9	36	21.7	20.9	41	22.0	21.2	36	21.7	20.9
33	19.2	18.9	37	19.3	18.9	42	19.2	19.2	37	19.2	18.9
34	19.6	20.3	38	19.3	20.0	43	19.3	19.9	38	19.3	20.0
35	16.8	18.2	39	16.6	18.0	44	16.8	18.2	39	16.8	18.2

Table A-3 (Continued)

	1966			1970			1975[a]				
	Percent of Five-Year Age Groups			Percent of Five-Year Age Groups			Percent of Five-Year Age Groups		Age in	Median Percent	
Age	Male	Female	Age	Male	Female	Age	Male	Female	1970[b]	Male	Female[c]
36	21.2	21.1	40	21.5	21.6	45	21.0	21.1	40	21.1	
37	21.6	21.6	41	21.6	21.4	46	21.0	21.5	41	21.6	
38	19.8	19.8	42	19.5	19.7	47	20.5	20.1	42	19.8	
39	19.2	19.4	43	18.8	18.9	48	18.8	18.9	43	18.9	
40	18.2	18.1	44	18.5	18.4	49	18.8	18.5	44	18.5	
41	19.6	20.7	45	19.8	20.8	50	19.8	21.2	45	19.8	20.8
42	19.9	20.3	46	20.2	20.3	51	20.3	20.0	46	20.2	20.3
43	21.1	20.8	47	21.2	20.7	52	21.6	20.6	47	21.2	20.7
44	20.3	19.6	48	20.0	19.5	53	19.7	19.5	48	20.0	19.5
45	19.0	18.6	49	18.9	18.7	54	18.6	18.7	49	18.9	18.7
46	22.6	22.2	50	22.9	22.4	55	23.3	22.6	50	22.9	22.4
47	19.3	18.5	51	19.4	18.8	56	19.6	18.4	51	19.4	18.5
48	19.3	19.4	52	19.0	19.0	57	18.9	19.3	52	19.0	19.3
49	19.6	20.4	53	19.0	19.5	58	19.5	19.8	53	19.5	19.8
50	19.2	19.5	54	19.6	20.4	59	18.7	19.8	54	19.2	19.8
51	21.5	21.1	55	21.8	21.4	60	22.6	21.7	55	21.6	
52	20.0	19.4	56	20.3	19.9	61	20.3	20.0	56	20.0	
53	19.8	20.2	57	20.2	20.3	62	20.4	20.3	57	20.2	
54	19.8	20.1	58	19.2	19.6	63	19.0	19.3	58	19.4	
55	19.0	19.1	59	18.4	18.8	64	17.6	18.7	59	18.8	
56	23.1	22.1	60	23.8	22.7	65	23.6	21.8	60	23.6	22.1
57	22.0	21.4	61	22.0	21.4	66	23.8	21.6	61	22.0	21.4
58	19.7	19.7	62	19.9	19.8	67	19.3	20.0	62	19.7	19.8
59	17.1	18.1	63	16.6	17.4	68	15.9	17.6	63	16.6	17.6
60	18.0	18.7	64	17.7	18.7	69	17.4	19.0	64	17.7	18.7

[a]1975 age distributions are based on the 5-percent sample.

[b]For ages 0-4 in 1970 the median percent is based solely on ages 5-9 in 1975 as follows:

Age in 1970	*Median Percent*
0	20.5
1	20.5
2	20.2
3	19.2
4	19.7

[c]Equal to male values except where indicated.

undercounts by five-year age groups, thereby smoothing out many of the differences from census to census at individual ages; and second, to utilize the repeated enumeration of each cohort in the three censuses to estimate the size of each single-year cohort relative to the larger cohort spanning several ages of which it is a member. (These steps are described in more detail below.)

If one abstracts from the individual peaks and hollows in the series of points in Figure A-3, one can see a pattern of census survival ratios: well above 1.0 at ages 0 and 1, varying around 1.0 from about age 3 to 10 or 11, falling below 1.0 through the mid-teens, climbing above 1.0 again in the late teens or early twenties, and finally returning to variations around 1.0 from the late twenties on, at least into the fifties. The ratios for the two intercensal periods have a similar general structure, although the ratios are higher for 1970–1975 at the first two ages, somewhat lower in the early teens, and generally higher from the mid-teens until the mid-twenties. The general similarity of pattern suggests that indeed there may have been similar rates of relative omission in the three censuses by broad age groups. In Figure A-4 the ratios of census survival rates to life table survival rates are shown by age intervals of a length that corresponds to the duration of the intercensal interval, namely four-year age intervals from 1966 to 1970 and five-year age intervals from 1970 to 1975.

In Figure A-4 the irregularities caused by particular features of single-year enumeration are to a large extent canceled out. The higher ratio of census to life table survival rates in early childhood for the second intercensal period is evident, as are the other differences noted from Figure A-3. The sawtooth pattern of alternate ups and downs after age 20 for the second intercensal period reflects an apparent tendency for slightly more complete enumeration in the latter half of each age decade: the fraction apparently surviving from ages ending in numerals 0–4 to ages ending in numerals 5–9 is always higher than in a life table, whereas apparent survival from ages ending in 5–9 to those ending in 0–4 is always somewhat lower than in a life table. This tendency could be the result of a reluctance to report a year of birth that puts the individual into the next age decade. This tendency shows up less clearly in survival rates from 1966 to 1970 because the four-year time interval requires the use of four-year age intervals that do not mesh with age decades, as do quinquennial age intervals.

To estimate relative completeness of enumeration by grouped ages in the three censuses, we used an adaptation of a method first employed by Demeny and Shorter (1968) in estimating the true age distributions in a series of censuses in Turkey. The procedure generates estimates of the completeness of enumeration by age intervals of the same length as the

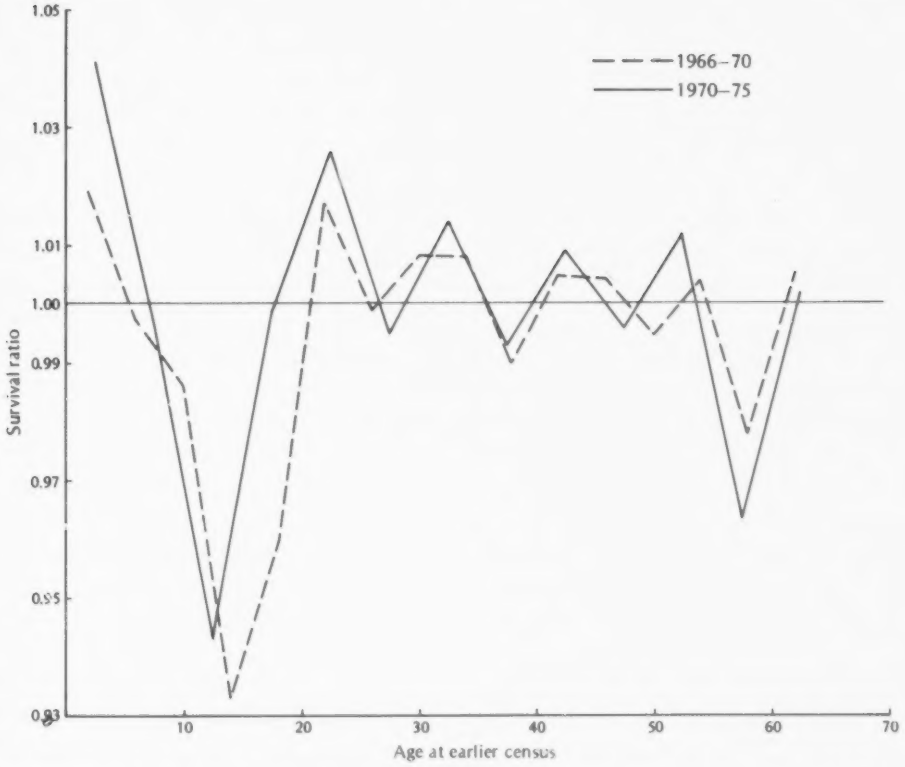


FIGURE A-4 Survival ratios, females, 1966–1970 and 1970–1975, by four-year and five-year age intervals, respectively: Republic of Korea.

interval between two consecutive censuses, on the basis of estimated survival rates for the intercensal period and an assumption that the completeness of enumeration of each age group is the same in each of the two censuses.

Details of the Demeny-Shorter Method of Adjusting Age Distributions

Suppose that the numbers of persons enumerated in the first of two censuses in age intervals 1, 2, 3, 4, . . . are designated as A_1, A_2, A_3, A_4, . . . , and in the second of two censuses as B_1, B_2, B_3, B_4, ... The width of the age intervals is equal to the time difference between the dates of the two censuses. This choice of intervals implies that persons in the second age interval in the second census (B_2) are the survivors of the group A_1 in the first census. Suppose that the survival factors p_1, p_2, p_3, . . . , which denote the proportions surviving from the first age interval to the

second, and so on, are known. Now make the provisional assumption (subject to later change) that the number of persons in the first census and the earliest age interval (A_1) is correctly recorded; then designate the correct number of persons by an asterisk: we thus assume provisionally that $A_1^* = A_1$. Then $B_2^* = p_1 A_1^*$, and the adjustment factor needed to correct any error in B_2 is $R_2 = B_2^*/B_2$.

The adjustment factor R_2 can then be used to multiply A_2 to generate an estimate of A_2^*. Repeated application of this procedure creates an adjusted population at all ages, based on the stated assumptions of knowledge of the correct survival rates, the existence of the same degree of completeness of enumeration at each age interval in the two censuses, and the provisional assumption that A_1^* equals A_1. We may now form the sum of all of the values of A_i^* to get a provisional estimate of the total population. To obtain estimates of *relative* undercount (which is all that this system can yield unless there is independent evidence of the completeness of coverage of some segment of the population), the values of A_i^* can be normalized by multiplying each A_i^* by a scalar so chosen that the sum is the same as the recorded total population. This normalization will rectify whatever error is introduced by the original provisional assumption that A_1^* equals A_1. For example, if A_1 were really undercounted by 10 percent, the provisional estimate of B_2^* would be 10 percent too small. This shortfall would lead in turn to a reduction by 10 percent of all of the subsequent values of A_i^*, and the sum of the set of A_i^*'s would also be 10 percent too small. Normalization would increase A_1^*, (and all A_i^*'s) by 10 percent. In other words, the provisional assumption makes no difference to the final set of estimated adjustment factors.

Application of Demeny-Shorter Procedure to the Korean Censuses of 1966, 1970, and 1975

Because of the noncomparability of the determination of age in the 1960 census with other censuses, the use of the Demeny-Shorter procedure was limited to the intercensal periods 1966–1970 and 1970–1975. Survival rates were taken from the life tables previously described. Adjustment factors (R_i) were generated for four-year age intervals for 1966–1970, and for five-year intervals for 1970–1975. The R_i's for 1966–1970 have been rather crudely converted to five-year intervals by linear interpolation. The calculated R_i's by five-year intervals for 1966–1970 and 1970–1975 are shown in Table A-4 along with the ratios of the R_i's in the two intercensal intervals. Since 1970 belongs to both intercensal intervals, the assumption of similar patterns of completeness of enumeration by age in each pair of censuses implies that the two sets of R_i's should be essentially the same. As

TABLE A-4 Calculated Preliminary Adjustment Factors (R_i), Females 1966-1970 and 1970-1975,[a] before and after Special Corrections: Republic of Korea

Table A-4a: R_i Adjustments before Special Corrections

Age Group	1966-1970	1970-1975	Ratio
	(1)	(2)	(1) ÷ (2)
0-4	0.9559	1.0086	0.948
5-9	0.9428	0.9694	0.973
10-14	0.9527	0.9732	0.979
15-19	1.0128	1.0320	0.981
20-24	1.0650	1.0334	1.031
25-29	1.0510	1.0077	1.043
30-34	1.0466	1.0127	1.033
35-39	1.0363	0.9982	1.038
40-44	1.0438	1.0050	1.039
45-49	1.0381	0.9959	1.042
50-54	1.0384	0.9999	1.039
55-59	1.0373	0.9883	1.050
60-64	1.0594	1.0268	1.032

Table A-4b: R_i Adjustments after Special Corrections

Age Group	1966-1970	1970-1975	Ratio
	(1)	(2)	(1) ÷ (2)
0-4	0.9975	0.9984	0.999
5-9	0.9798	0.9786	1.001
10-14	0.9901	0.9825	1.008
15-19	1.0419	1.0418	1.000
20-24	1.0399	1.0432	0.997
25-29	1.0236	1.0173	1.006
30-34	0.9956	0.9971	0.998
35-39	0.9788	0.9829	0.996
40-44	0.9859	0.9895	0.996
45-49	0.9805	0.9806	1.000
50-54	0.9808	0.9845	0.996
55-59	0.9798	0.9731	1.007
60-64	1.0006	1.0110	0.990

Special corrections:
1966, 15-19: 0.950
25-29: 0.965
1970, 0-4: 1.020
25-29: 0.990
1975, 30-34: 1.015

[a]Female 1975 age distribution is based on the 5-percent sample.

the ratio column in Table A-4a makes clear, however, the R_i's for the first intercensal period are a few percent lower than in the second intercensal period for ages up to the mid-teens and then rise to a set of values that are more or less uniformly higher at ages above 30. The almost uniform ratios for the early part of the age span and for the later part of the age span suggest that there are only a few ages (from about 15 to 30) in which there is an important deviation from the assumption of a similar pattern of errors in the three censuses. In other words, there must have been a difference in completeness of reporting at early adult ages among the three censuses. This difference is also evident from Figure A-4, in which it can be seen that the undercount of those aged 0–4 in 1970 relative to those aged 5–9 in 1975 was greater than the undercount of very young children in 1966 compared to their later enumeration in 1970. Similarly, the enumeration of women in their early twenties in 1970 was more deficient relative to enumeration of women in their late teens in 1966 than the approximately corresponding age groups in the censuses in 1970 and 1975.

The Demeny-Shorter procedure is predicated on proportionate understatements and overstatements that are the same in consecutive censuses; the method creates the adjustment factors implied by this assumption. The two sets of R_i's for 1966–1970 and 1970–1975 should both be applicable to 1970 and thus should be equal. The discrepancies between the R_i's in Table A-4a are the result of particular differences in understatement or overstatement at certain ages among the three censuses. After experimentation with various possible choices, special individual adjustments were made to particular age groups in the three censuses so as to make the two sets of R_i's nearly equal. The aim was to introduce a minimum of special adjustments and yet to assure essential uniformity in the two sets of R_i's. The special adjustments listed at the bottom of Table A-4 were constructed by eliminating the major inconsistencies between the 1966–1970 and the 1970–1975 survival ratios shown in Figure A-4. They include the assumptions that in 1966 the age intervals 15–19 and 25–29 were undercounted less than in the other censuses (5 percent for the former group and 3.5 percent for the latter); that in 1970 the age group 0–4 was undercounted by an extra 2 percent and the age group 25–29 was undercounted by 1 percent less; and that in 1975 the age group 30–34 was subject to an extra 1.5 percent undercount. These special adjustments led to sets of R_i's for the two intercensal levels that differed by less than 1 percent (Table A-4b).

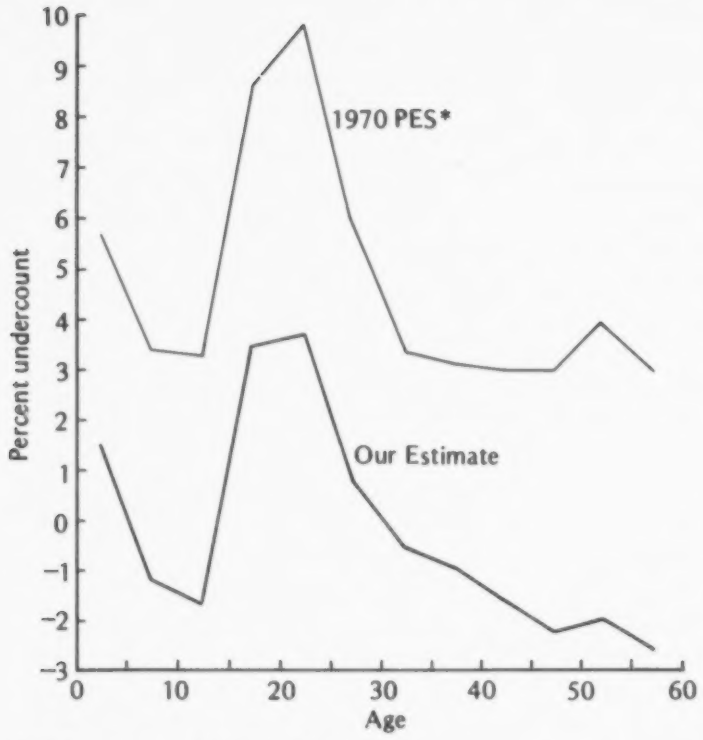
The special adjustments and the resulting R_i's were then applied to the reported five-year age distributions in the three censuses to yield provisional estimates of the female age distribution by five-year intervals. For 1966 the R_i's of 1966–1970 were applied; for 1975 the 1970–1975 R_i's

were applied; and for 1970 the average of the two. The nature of the adjustments guarantees that, within the limits of interpolation and averaging, the adjusted size of every cohort was necessarily consistent across the three censuses.

As was noted earlier, the adjustments just described provide indications only of *relative* undercounts and overcounts. If the censuses in addition are subject to an overall omission rate of several percent, the calculated R_i's would be unaffected. In Figure A-5, the estimated undercounts in 1970 have been arbitrarily adjusted (by multiplication of the adjusted populations by an appropriate constant) to yield complete coverage, on the average, of ages 5–14 in 1975. The set of estimated undercounts by age was compared with estimates derived from the Post-Enumeration Survey (PES) of the 1970 census (Cho 1974b). The PES consisted of an intensive recanvass of a representative sample of districts to produce in these areas an independent list of persons classified by age and sex; this list was checked against the census list of the same persons on a name-by-name basis. Despite the wholly different basis of the figures, our estimated pattern of undercounts by age agrees closely with the PES results: both sets of estimates show the particularly high undercounts in the age groups 0–4, 15–19, 20–24, and 25–29, as well as the less marked peak in the age group 50–54.

Estimates of Single-Year Female Age Distribution in 1966, 1970, and 1975

To achieve the goal of estimating fertility from the age distribution for 1955–1975, the most important need is an accurate determination of the number of persons at individual ages for those under 20 in 1975 and under 15 in 1970. It would be advantageous as a contribution to more accurate knowledge of the Korean population to have estimates of the number of persons at other individual ages as well. Therefore, single-year estimates were constructed. The size of each single-year cohort relative to the size of the five-year cohort of which it is a member was determined in each census (1966, 1970, and 1975) for each sex. At any given census, a single-year cohort might be counted as unusually large or unusually small either because of genuine differences in cohort size or because of peculiarities in the count for that particular age and sex in that year. However, with three census age distributions for each sex, there are six records of the relative size of the cohort over a five-year time interval. Except for the ages of high mortality, in infancy and at the end of the span of life, the relative sizes of a single-year cohort and the five-year cohort to which it belongs would not change very much between 1966 and 1975. In effect, then, the six figures



*Based on Cho (1974b: Table 1-4b).

FIGURE A-5 Estimated female undercounts (percent) by five-year age group in the 1970 census: comparison with Post-Enumeration Survey: Republic of Korea.

for relative size (three censuses and two sexes) are six values of a number that in each instance would be approximately the same if all the data were accurate. The median of the six values was selected as the final estimate of the relative size of each cohort.[5] The median ratio of the size of each single-year cohort to the size of the five-year cohort was applied to the appropriate corrected five-year age group to estimate the number at each individual age.

The relative sizes of the single-year cohorts and the five-year age groups in the three censuses are shown for the population that was aged 1–60 in 1966 in Table A-3. Note that for most cohorts the ratio varies only slightly from census to census. Note in particular that certain cohorts (for example, those that were aged 5, 13, 14, 17, and 19 in 1970) are seen as

consistently small and that others (e.g., those that were 10 and 15 in 1970) are consistently large.

After corrected single-year distributions of the female population had been constructed, it was a matter of simple reverse projection (utilizing life tables already constructed) to calculate single-year age distributions at the dates of the censuses of 1955 and 1960. Because of the awkwardness arising from the four-year interval between the 1966 and 1970 censuses, the single-year estimates for 1966 were rederived by reverse projection from 1970. Figures A-6 through A-10 show the recorded and adjusted age distributions at all five censuses, and Figures A-11 through A-15 show the estimated undercounts by age. In Figures A-11 and A-12, cohorts born in leap years are indicated by a dot below the estimated undercount. Note that leap-year cohorts were usually overcounted (or undercounted less than neighboring cohorts) in 1955 and also in 1960, despite the different basis for age determination in the latter census. Percent undercounts by single years of age for females in all five censuses are also given in Table A-5. (The overall level of undercounts is set by an arbitrary assumption of complete coverage, on the average, at ages 5–14 in 1975.)

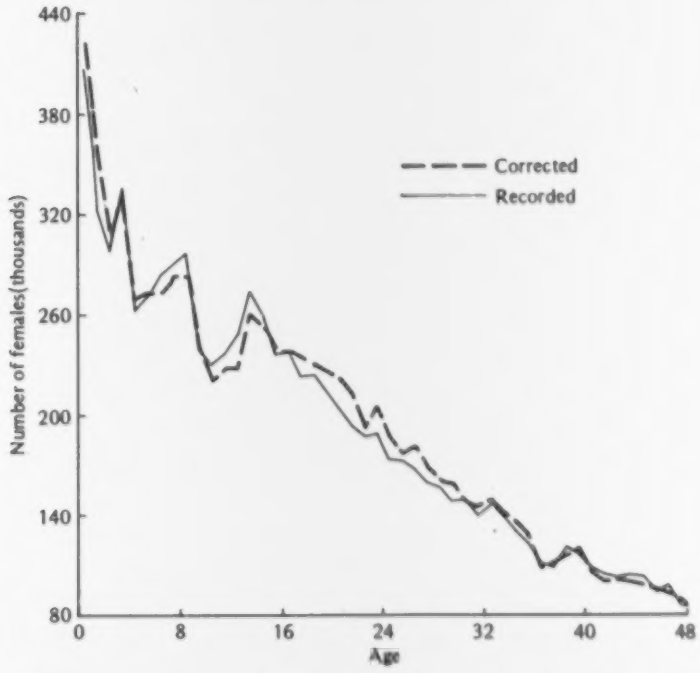


FIGURE A-6 Recorded and corrected female age distribution, 1955 census: Republic of Korea.

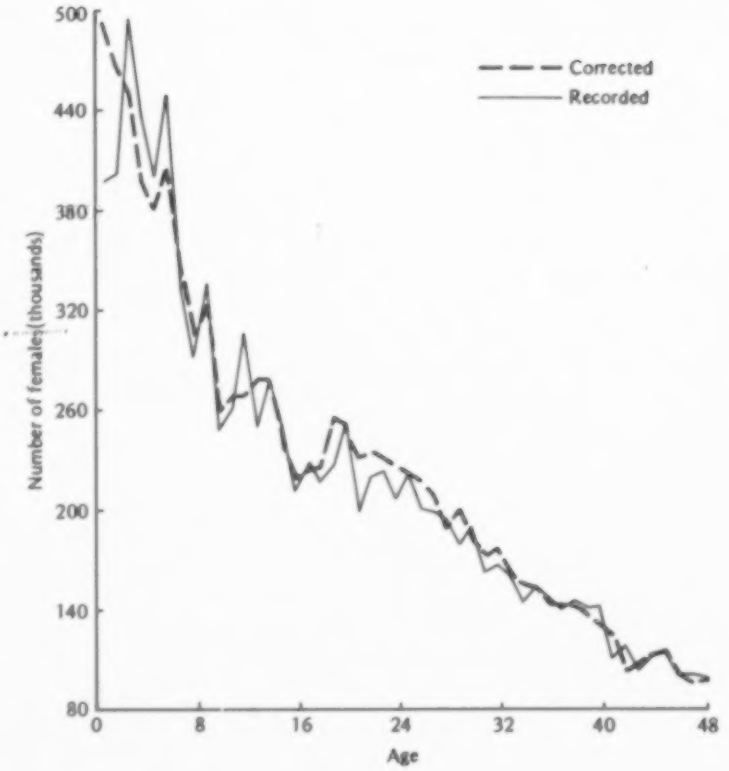


FIGURE A-7 Recorded and corrected female age distribution, 1960 census: Republic of Korea.

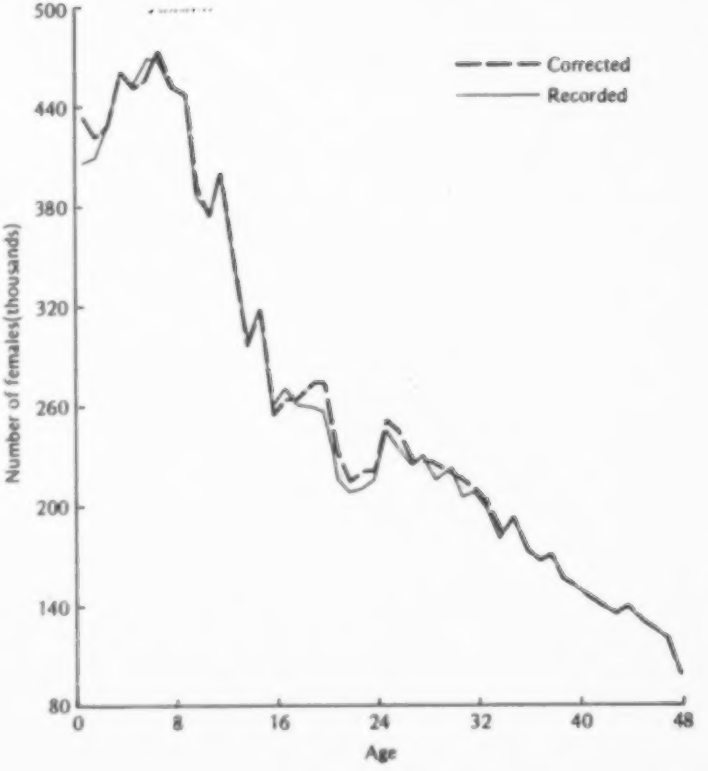


FIGURE A-8 Recorded and corrected female age distribution, 1966 census: Republic of Korea.

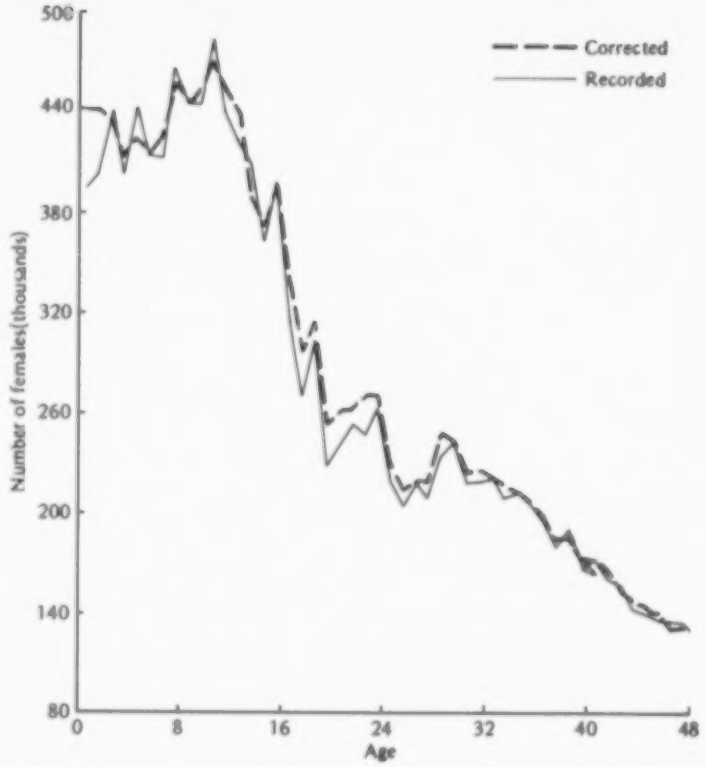


FIGURE A-9 Recorded and corrected female age distribution, 1970 census: Republic of Korea.

FIGURE A-10 Recorded and corrected female age distribution, 1975 census: Republic of Korea.

NOTE: Recorded data are as recorded in the 5-percent sample age distribution.

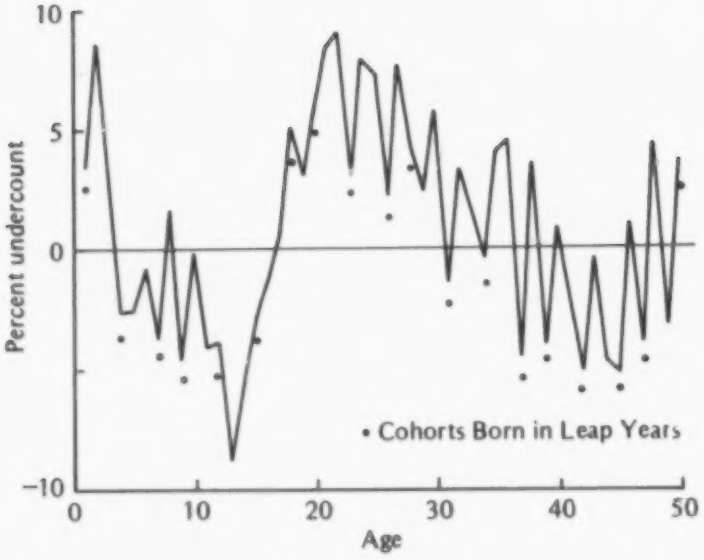


FIGURE A-11 Percent undercount by single years of age, females, 1955 census: Republic of Korea.

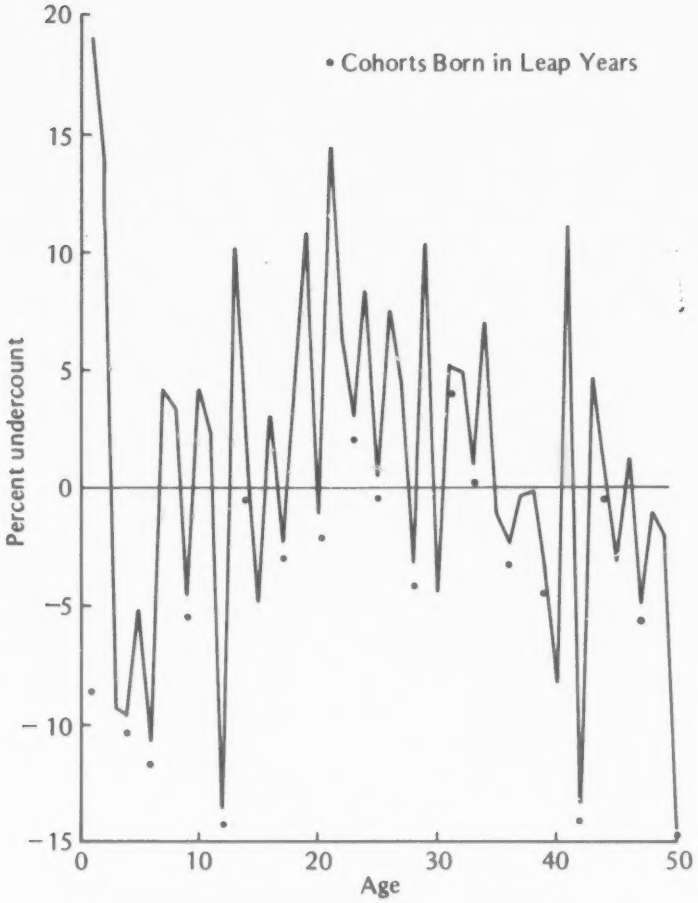


FIGURE A-12 Percent undercount by single years of age, females, 1960 census: Republic of Korea.

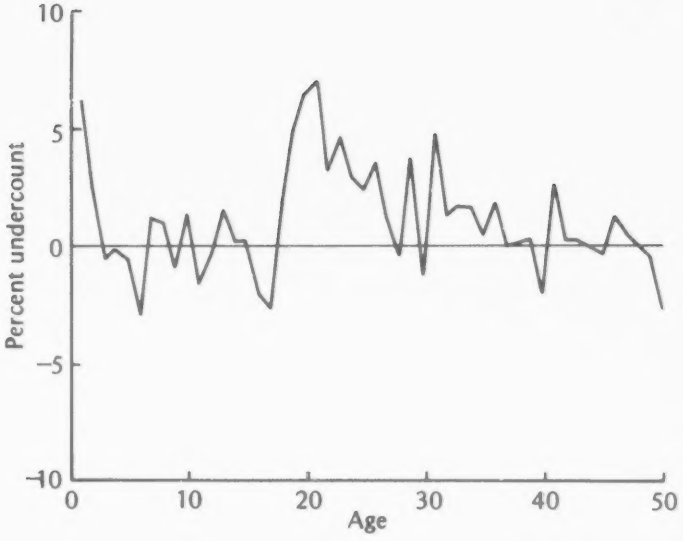


FIGURE A-13 Percent undercount by single years of age, females, 1966 census: Republic of Korea.

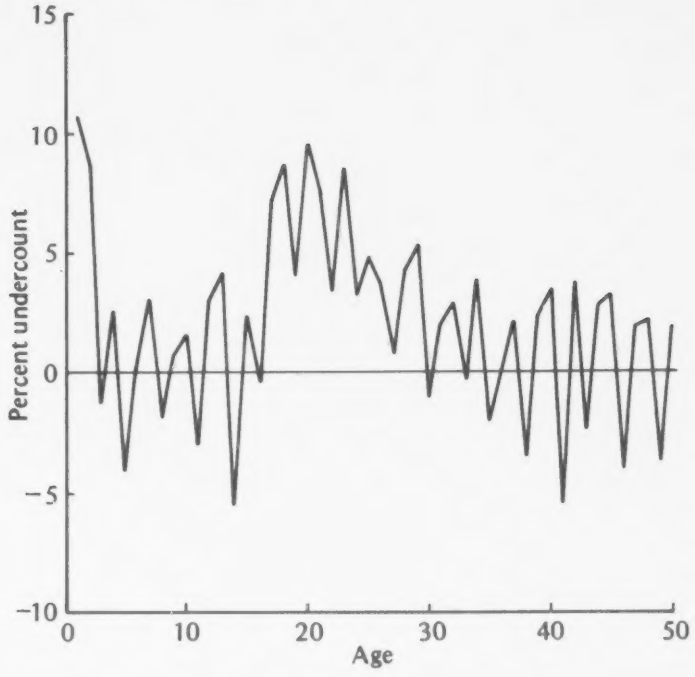


FIGURE A-14a Percent undercount by single years of age, females, 1970 census: Republic of Korea.

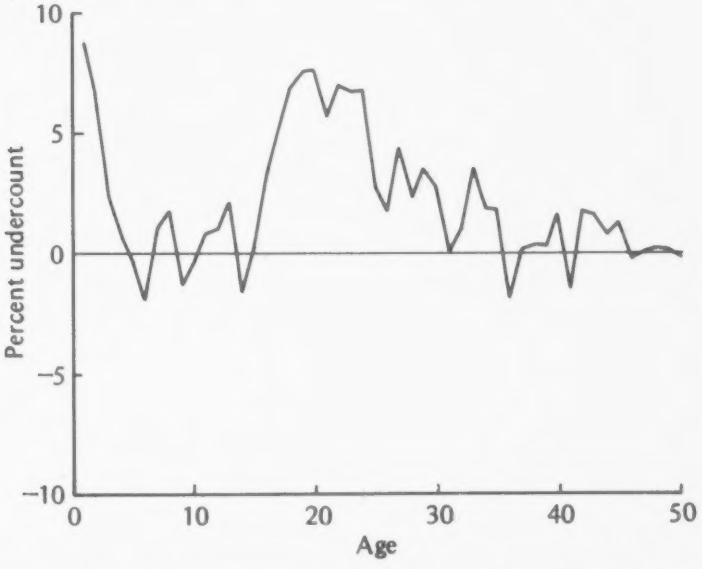


FIGURE A-14b Percent undercount by single years of age after correcting for leap years, females, 1970 census: Republic of Korea.

TABLE A-5 Percent Undercounts[a] by Single Years of Age for Females, 1955, 1960, 1966, 1970, and 1975 Censuses: Republic of Korea

Age at Census	1955	1960	1966	1970	1975[b]	
					5-Percent Sample	Complete Count
0	3.6	19.1	6.3	10.7	–	–
1	8.6	13.8	2.5	8.5	–	–
2	3.2	-9.3	-0.4	-1.2	–	–
3	-2.6	-9.6	-0.0	2.6	–	–
4	-2.5	-5.2	-0.5	-4.1	–	–
5	-0.7	-10.7	-3.0	0.2	-0.9	-0.6
6	-3.6	4.3	1.2	3.1	-0.1	-1.2
7	1.6	3.4	1.0	-1.9	0.4	0.1
8	-4.4	-4.5	-0.9	0.8	-0.7	-0.8
9	-0.0	4.2	1.5	1.7	0.3	0.8
10	-4.1	2.4	-1.5	-2.9	-0.1	-0.5
11	-3.9	-13.6	-0.3	3.0	-0.9	0.8
12	-8.6	10.3	1.5	4.2	-0.3	0.4
13	-5.2	0.9	0.2	-5.4	0.9	1.8
14	-2.7	-4.7	0.1	2.4	1.3	-0.8
15	-1.2	3.1	-2.2	-0.3	3.8	2.6
16	0.6	-2.3	-2.7	7.1	4.8	3.7
17	5.1	4.2	1.8	8.8	7.3	4.7
18	3.1	10.8	4.9	4.1	6.0	3.9
19	5.8	-1.1	6.4	9.6	8.0	4.7
20	8.4	14.4	6.9	7.6	6.0	4.4
21	9.1	6.3	3.2	3.5	9.4	7.9
22	3.2	3.1	4.6	8.6	6.4	4.7
23	7.9	8.5	2.9	3.3	3.9	3.2
24	7.4	0.6	2.4	4.8	3.6	3.2
25	2.3	7.5	3.5	3.8	4.7	3.8
26	7.6	4.6	1.1	0.9	2.9	2.4
27	4.2	-3.2	-0.4	4.3	2.9	4.9
28	2.3	10.4	3.6	5.5	3.4	3.9
29	5.7	-4.4	-1.2	-0.9	4.3	3.9
30	-1.3	5.3	4.7	2.1	7.9	4.8
31	3.3	5.0	1.4	3.0	1.7	2.8
32	1.4	1.1	1.7	-0.2	3.0	1.2
33	-0.4	7.0	1.6	3.9	3.1	2.8
34	4.0	-0.9	0.4	-1.9	0.3	0.6
35	4.6	-2.4	1.9	0.2	3.0	2.1
36	-4.4	-0.2	0.0	2.2	-0.2	-0.9
37	3.5	-0.0	0.1	-3.3	-0.2	0.9
38	-3.9	-3.3	0.3	2.4	-0.4	0.6
39	0.8	-8.1	-2.1	3.6	-1.0	-0.1
40	-2.0	11.2	2.7	-5.3	2.1	1.5
41	-5.0	-13.3	0.2	3.8	-0.1	1.1
42	-0.4	4.7	0.2	-2.2	-0.2	1.1
43	-4.6	1.1	-0.0	2.9	1.8	2.7

TABLE A-5 (continued)

Age at Census	1955	1960	1966	1970	1975[b] 5-Percent Sample	1975[b] Complete Count
44	-5.0	-3.0	-0.4	3.3	0.8	3.0
45	1.0	1.3	1.2	-3.9	-0.1	0.2
46	-3.9	-4.8	0.5	2.1	0.8	1.9
47	4.4	-0.9	-0.0	2.2	-1.3	-0.3
48	-3.1	-1.9	-0.5	-3.6	0.3	1.2
49	3.6	-14.3	-2.6	2.0	0.3	1.6

[a]The level of undercounts has been arbitrarily adjusted to yield a 0-percent undercount, on the average, for ages 5-14 in 1975 (5-percent sample).
[b]In the last two columns, undercounts are of the 5-percent sample and of the 100-percent tabulation respectively, relative to our corrected 1975 female population (Table A-6).

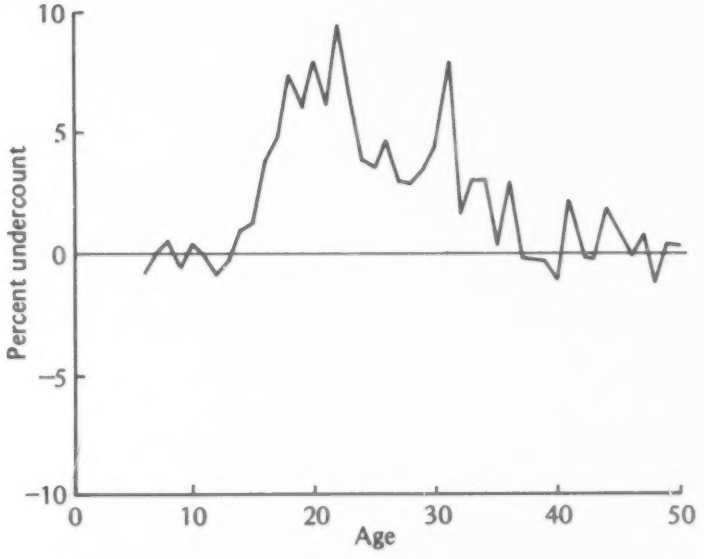


FIGURE A-15 Percent undercount by single years of age, females, 1975 census: Republic of Korea.

NOTE: Undercounts are of the 5-percent sample age distribution.

Estimates of Births and Fertility from 1955 to 1975

The rather complicated calculations just described have yielded corrected estimates of the female age distribution, by single years of age, from 1955 to 1975 for all cohorts up to age 69 in 1975 (Table A-6). The life tables employed in these calculations can also be used to project corrected single-

TABLE A-6 Corrected[a] Female Single-Year Age Distributions (in thousands), Censuses 1955-1975: Republic of Korea

Age	1955	1960	1966	1970	1975
0	421	491	434	442	378[b]
1	355	467	420	442	417[b]
2	308	451	430	436	429[b]
3	328	398	460	414	450[b]
4	263	380	451	425	449[b]
5	272	406	456	415	439
6	274	347	473	426	439
7	282	303	456	457	433
8	284	322	443	448	411
9	241	259	392	453	422
10	221	268	374	470	413
11	228	270	399	453	424
12	229	278	342	440	454
13	260	280	298	389	445
14	254	238	318	372	450
15	236	218	255	397	465
16	239	225	264	339	449
17	235	226	265	296	436
18	231	256	273	315	385
19	227	249	275	253	369
20	222	232	233	261	394
21	213	235	215	263	336
22	193	231	221	271	294
23	205	226	222	272	313
24	187	222	251	230	251
25	176	217	244	212	259
26	181	208	226	218	260
27	167	189	229	219	268
28	160	200	224	248	269
29	157	182	220	241	228
30	148	172	216	224	209
31	145	176	210	226	215

TABLE A-6 (continued)

Age	1955	1960	1966	1970	1975
32	149	162	202	221	216
33	141	155	183	217	244
34	136	153	193	212	237
35	129	144	176	207	220
36	107	141	166	199	222
37	113	144	171	180	218
38	117	137	157	190	214
39	118	132	150	173	209
40	106	125	146	163	204
41	100	104	139	167	195
42	102	109	136	153	177
43	100	113	139	146	187
44	98	114	131	143	170
45	96	102	126	136	160
46	95	96	120	133	163
47	90	98	99	135	150
48	82	96	104	128	143
49	90	94	107	122	140
50		91	107	116	131
51		90	100	96	128
52		85	93	100	131
53		78	94	103	123
54		85	91	103	118
55			88	96	111
56			87	89	91
57			85	90	95
58			79	86	98
59			71	84	98
60				82	88
61				80	82
62				74	83
63				66	79
64				70	77
65					73
66					71
67					66
68					58
69					62

[a]Age distributions are arbitrarily adjusted to yield a 0-percent undercount in ages 5-14 in 1975.

[b]Corrected 1975 population aged 0-4 is based on average of 1966 and 1970 correction factors for corresponding ages.

year cohorts back to birth, to provide consistent estimates of the number of female births for each year from 1955 to 1975.[6] The number of male births for each year can be estimated in turn as 1.075 times the number of female births.[7] The intercensal life tables previously constructed (Table A-2) incorporate mortality up to age 5 that is consistent with the average infant mortality rates for the time period in question, as reported in the 1971 Korean Fertility-Abortion Survey. To make rough allowance for the time trend of infant mortality, a value of ${}_1q_0$ for each year was estimated by linear interpolation between values for the surveyed years. A ${}_1L_0$ consistent with each individually estimated ${}_1q_0$ was used in projecting the cohort from under age 1 back to birth.

The number of female births, the crude birth rate, the general fertility rate, and the total fertility rate for each year from 1955 to 1975 are shown in Table 1.[8] The denominator of the general fertility rate (women aged 15–49) is obtained by reverse projection of the female population by single years to each date from 1955 to 1975.

The total fertility rate was calculated by incorporating the structure by age of fertility each year estimated by the own-children method (Cho 1971, 1974a; and unpublished preliminary calculations from the 1975 census). The age-specific fertility rates by five-year age intervals in the estimated own-children schedules were applied to the adjusted female age distributions to determine the number of births implied by these schedules and the corrected age distributions. The final estimate of age-specific fertility rates (from which total fertility was calculated) was a simple scaling up or down of the own-children schedule to yield the corrected number of births estimated for the appropriate year. Since own-children estimates of fertility began in 1957, total fertility rates for 1955 and 1956 were estimated from the trend in general fertility rates between 1955 and 1957. The birth cohort of 1955 was unusually large (probably because of the effect of demobilization after the Korean War); thus, the total fertility rate shown for 1955 is derived from the average number of births in 1954–1956.

In Figure A-16, the resultant total fertility rates are compared with the rates estimated by the own-children method. The new estimates are much less erratic in the late 1960s because of the adjustment of the 1970 age distribution for the leap-year effect.[9] The 20-year sequence of total fertility rates has two remarkable features—increases in the late 1950s before the decline began, and a decline, once begun, that reached nearly 50 percent in only 15 years.

FIGURE A-16 Corrected total fertility rates (15–49 year olds) and rates estimated by own-children method, 1955–1975: Republic of Korea.

SOURCES: Uncorrected own-children TFRs: 1957–1958 (Cho 1971); 1959–1970 (Cho 1974a); 1971–1975 (unpublished data from the 1975 census).

B THE FEMALE AGE DISTRIBUTION OF KOREA IN 1975 AS RECORDED IN THE COMPLETE COUNT AND IN THE 5-PERCENT SAMPLE

When the undercounts in the 1966, 1970, and 1975 censuses were estimated as the basis for our adjustments of own-children fertility schedules, the only available tabulations for 1975 were from a 5-percent sample. All references to the 1975 enumeration in the text of the report and in Appendix A are references to this sample. After our analysis was completed, the age distribution of the complete count was published. The distributions are not identical, and they differ at certain points by more than would be expected from random variation. Percent differences between the two distributions of the female population, by single years and five-year intervals, are shown in Table B-1.

The complete count is affected to a lesser extent by a characteristic of the 5-percent sample distribution, noted previously: an undercount at some ages divisible by five, especially age 30. The large dip at age 25 in the census survival rates from 1970 to 1975 (Figure A-1) would be less with the complete count distributions than with the sample. In other respects, the 1975 complete count distribution was less consistent with the 1970 census than was the 5-percent distribution (for example, in having smaller numbers at higher ages). The estimated relative size of single-year cohorts within five-year cohorts (Table A-3) would barely be changed by basing the estimates on the full count: for only one single-year cohort would the estimate be altered by as much as 1.5 percent. Thus, we concluded that estimates of the correct distribution from the complete count would be only slightly different from and not an improvement over the estimates presented.

TABLE B-1 Comparison of 1975 Female Age Distributions, by Single Years and Five-Year Age Groups, 5-Percent Sample vs. Complete Enumeration: Republic of Korea

Age	Percent Difference[a]	Age	Percent Difference	Age	Percent Difference
0-4	1.7	25-29	0.2	50-54	1.2
0	4.1	25	-0.8	50	3.7
1	1.0	26	-0.5	51	-0.5
2	1.5	27	2.1	52	0.1
3	2.9	28	0.6	53	1.1
4	-0.6	29	-0.5	54	1.7
5-9	-0.2	30-34	-0.7	55-59	1.4
5	0.3	30	-3.3	55	4.0
6	-1.1	31	1.2	56	-0.5
7	-0.3	32	-1.9	57	1.2
8	-0.0	33	-0.3	58	1.0
9	0.5	34	0.3	59	1.0
10-14	0.1	35-39	0.3	60-64	-1.4
10	-0.4	35	-0.9	60	-1.0
11	1.7	36	-0.7	61	-1.1
12	0.7	37	1.2	62	-0.3
13	0.9	38	1.0	63	-3.0
14	-2.1	39	0.9	64	-2.0
15-19	-2.1	40-44	1.0	65-69	2.4
15	-1.3	40	-0.6	65	-0.6
16	-1.2	41	1.2	66	-1.3
17	-2.7	42	1.3	67	4.8
18	-2.2	43	1.0	68	5.3
19	-3.4	44	2.2	69	5.0
20-24	-1.3	45-49	0.9	70-74	2.3
20	-1.7	45	0.3	70	-1.4
21	-1.7	46	1.2	71	4.4
22	-1.7	47	1.0	72	3.1
23	-0.8	48	0.9	73	3.3
24	-0.4	49	1.3	74	2.6

[a]Percent difference = (5-percent sample – complete count) ÷ complete count.
SOURCES: Economic Planning Board, Korea (1976: 24-26) and (1977: 22-33).

C COMPARISON OF AVERAGE INCREASES IN PARITY FROM 1970 TO 1975 (CENSUS COHORT BIRTH RATE) WITH NUMBER OF REGISTERED BIRTHS PER WOMAN (REGISTERED COHORT INTERCENSAL BIRTH RATE)

The comparison of census cohort birth rates and registered cohort intercensal birth rates requires precise synchronization of fertility data recorded in different ways. Registered births are recorded for cohorts that are at exact age x to $x + 1$ at the midpoint of 1971, $x + 1$ to $x + 2$ at the midpoint of 1972, and $x + 4$ to $x + 5$ at the midpoint of 1975. The relevant data from the censuses on cohort size are numbers of persons at exact ages y to $y + 1$ on October 1, 1970, and $y + 5$ to $y + 6$ on October 1, 1975. The average size of the cohort that was x to $x + 1$ in mid-1971 was estimated as

$$\frac{3}{4}\left(\frac{P^{70}_{x-1} + P^{75}_{x+4}}{2}\right) + \frac{1}{4}\left(\frac{P^{70}_{x} + P^{75}_{x+5}}{2}\right). \qquad \text{(C-1)}$$

The numbers in parentheses are the estimated sizes of two consecutive cohorts enumerated in the censuses, with the weights of 3/4 and 1/4 allowing for the 3/4 year displacement between October 1 and the midpoint of the following year. Dividing the sum of the registered births at x to $x + 1$ in 1971, $x + 1$ to $x + 2$ in 1972, . . . , and $x + 4$ to $x + 5$ in 1975 by the average size of cohort gives the five-year increase in cumulated fertility (i.e., the intercensal cohort birth rate) for women who were at exact age x on January 1, 1970. The increase in parity between the two censuses is the average number of births to women who were y to $y + 1$ or, on the average, $y + 0.5$ years of age on October 1, 1970, and became $y + 5.5$ years of age on October 1, 1975. The possible difference in average number of births per woman in a five-year period beginning on October 1 and in one beginning on December 31 was taken as negligible; but the difference in age of 1/2 year between the cohorts experiencing registered births and the cohorts enumerated in the censuses could not be ignored. To determine the census cohort birth rate comparable to the registered cohort birth rate, cohort birth rates of persons x to $x + 1$ were calculated from rates for persons $x + 0.5$ to $x + 1.5$ by quadratic interpolation.

Before the registered cohort birth rates were computed, a preliminary adjustment was applied to the numbers of registered births listed for 1975. The unadjusted birth rates for individual years are[10]:

Year	Crude Birth Rate
1971	28.3
1972	25.0
1973	23.9
1974	20.4
1975	12.8

The sharp decline from 1974 to 1975 is not credible—the birth rate fell more or less smoothly in the other years before this precipitous drop. The source of this discontinuity is a combination of delayed registration and the cutoff date of December 31, 1976. Therefore an assumption was introduced that the average decline during 1971–1974 persisted through 1975, and a special adjustment in the form of a 39-percent increase in the number of registered births was made in 1975, to raise the registered figures for that year to approximately the level of underregistration prevailing in the earlier years.

Notes

1. Practical estimation by the own-children method must utilize tabulations of women and children in finite age intervals, rather than as numbers that are continuous functions of age, as implied in equation (2). This equation is intended to illustrate the logical basis, not the computational steps, of own-children estimation. It therefore avoids complicated problems of the relations between cohort and period experience in a given age interval, problems involving the use of Lexis diagrams that often are encountered in demographic calculations. There is an additional practical problem of allocating to women at different ages the small fraction of children who are not identified as any woman's own children. These questions are rigorously analyzed in Cho and Feeney (1978).

2. What the own-children technique adds to the general fertility rate as an aggregate measure of fertility is evidence of the age pattern of fertility, so that the total fertility rate, an age-distribution-free measure of fertility, can be estimated. The general fertility rate is age distribution free in that it is independent of variations in how large a fraction of the population is constituted of women of childbearing age. It is not independent of different concentrations of women within the childbearing span at the most prolific ages, as is the total fertility rate.

3. The first census for the Republic of Korea was conducted in 1948, but most of the data were destroyed during the Korean War.

4. The effect of the use of both lunar and solar calendars on age misreporting in the Korean censuses is analyzed for censuses prior to 1970 by Kwon (1977).

5. For certain five-year cohorts in which relative numbers of males had been strongly affected by participation in World War II or the Korean War, the estimate of cohort size for females is based on the three enumerations of the female cohort alone. These were ages 35–39, 45–54, and 60–64 in 1970.

6. To construct estimates for 1970–1975, it is necessary to adjust the single-year distribution under age 5 in the 1975 census for misreporting. No empirical basis for such adjustment exists; we have assumed corrections equal to the average of those calculated for 1966 and 1970.

7. A ratio of males to females at birth as high as 1.075 is required to be consistent with the uniformly high proportions of males in the child populations. This sex ratio is at the high end of reliably reported ratios based on large numbers of births. The sex ratio is 1.07 or above in Poland, Yugoslavia, and Hungary. Assigning a lower number of male births would have lowered our estimates by less than 1 percent.

8. Since the most recent censuses were conducted on October 1 and own-children estimates are based on reported ages at the time of the census, these annual fertility measures refer to a year ending on October 1 rather than to an actual calendar year.

9. Because no two leap years occur consecutively and because the excess births in leap years are borrowed from neighboring non-leap years, the corrections for the lunar calendar would have been closely approximated by a two-year moving average of the total fertility rates.

10. Registered births for 1971–1975 are taken from Feeney (1977).

Glossary

AGE HEAPING A tendency for enumerators or respondents to report certain ages instead of others; also called age preference or digit preference. Preference for ages ending in 0 or 5 is widespread.

AGE PATTERN OF FERTILITY The relative distribution of a set of *age-specific fertility rates*. It expresses the relative contribution of each age group to *total fertility*.

AGE-SPECIFIC FERTILITY RATE The number of births occurring during a specified period to women of a specified age or age group, divided by the number of person-years-lived during that period by women of that age or age group. When an age-specific fertility rate is calculated for a calendar year, the number of births to women of the specified age is usually divided by the midyear population of women of that age.

AGE STANDARDIZATION A procedure of adjustment of crude rates (birth, death, or other rates) designed to reduce the effect of differences in age structure when comparing rates for different populations.

BIRTH HISTORY A record of the number and dates of all live births experienced by a particular woman; see also *pregnancy history*. Survival of each child to the date of the interview and, where pertinent, the date of death are also generally recorded.

BIRTH ORDER The ordinal number of a given live birth in relation to all previous live births of the same woman (e.g., 5 is the birth order of the fifth live birth occurring to the same woman).

BIRTH RATE See *crude birth rate*.

CHILDBEARING AGES The span within which women are capable of bearing children, generally taken to be from age 15 to age 49 or, sometimes, to age 44.

CHILDREN EVER BORN(E) The number of children ever borne alive by a particular woman; synonymous with *parity*. In demographic usage, stillbirths are specifically excluded.

COHORT A group of individuals who experienced the same event in the same period. Thus an age cohort is a group of people born during a particular period, and a marriage cohort is a group of people who married during a particular period. The effects of a given set of mortality or fertility rates are often illustrated by applying them to hypothetical cohorts.

COHORT FERTILITY The fertility experienced over time by a group of women or men who form a birth or a marriage cohort. The analysis of cohort fertility is contrasted with that of *period fertility*.

CRUDE BIRTH RATE The number of births in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as births per thousand population. The crude birth rate for a single year is usually calculated as the number of births during the year divided by the midyear population.

CRUDE DEATH RATE The number of deaths in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as deaths per thousand population. The crude death rate for a single year is usually calculated as the number of deaths during the year divided by the midyear population.

CUMULATED FERTILITY An estimate of the average number of children ever borne by women of some age x, obtained by cumulating *age-specific fertility rates* up to age x; also often calculated for age groups.

DEATH RATE See *crude death rate*.

EXPECTATION OF LIFE AT BIRTH The average number of years that a member of a *cohort* of births would be expected to live if the cohort were subject to the mortality conditions expressed by a particular set of age-specific mortality rates.

FERTILITY HISTORY Either a *birth history* or a *pregnancy history*.

FORWARD SURVIVAL A procedure for estimating the age distribution at some later date by projecting forward an observed age distribution. The procedure uses *survival ratios*, often obtained from model *life tables*. The procedure is basically a form of population projection without the introduction of new entrants (births) to the population.

GENERAL FERTILITY RATE The ratio of the number of live births in a period to the number of person-years-lived by women of *childbearing ages* during the period. The general fertility rate for a year is usually calculated as the number of births divided by the number of women of childbearing ages at midyear.

GROSS REPRODUCTION RATE The average number of female children a woman would have if she survived to the end of her childbearing years and if, throughout, she were subject to a given set of *age-specific fertility rates* and a given *sex ratio at birth*. This number provides a measure of replacement fertility in the absence of mortality.

GROWTH RATE The increase or decrease of a population in a period divided by the number of person-years-lived by the population during the same period. The

increase in a population is the result of a surplus (or deficit) of births over deaths and a surplus (or deficit) of immigrants over emigrants. (The annual increase is often expressed as a fraction of the total population at the beginning of the year, but this convention has the inconvenient characteristic of not being readily defined for a five-year interval and of being unequal to the difference between the birth rate and the death rate even in the absence of migration.) See also *rate of natural increase*.

INFANT MORTALITY RATE The number of deaths of children under 1 year of age occurring in a year per 1,000 live births occurring in the same year; also used in a more rigorous sense to mean the number of deaths that would occur under 1 year of age in a *life table* with a *radix* of 1,000.

LIFE TABLE A listing of the number of survivors at different ages (up to the highest age attained) in a hypothetical cohort subject from birth to a particular set of age-specific mortality rates. The rates are usually those observed in a given population during a particular period of time. The tabulations accompanying a life table include other features of the cohort's experience: its expectation of life at different ages, the probability of surviving from the beginning of each age interval to the end of that interval, etc.

MARITAL FERTILITY Any measure of fertility in which the births (in the numerator) are births to married women and in which the number of person-years-lived (in the denominator) also pertains to married women. In some instances, the designation "married" includes persons in consensual unions.

MEDIAN The central value of a set that is ordered by size or some other characteristic expressed in numbers.

MEAN AGE OF CHILDBEARING The average age at which a mortality-free *cohort* of women bear their children according to a set of *age-specific fertility rates*.

MEAN AGE OF CHILDBEARING IN THE POPULATION The average age of the mothers of the children born in a population during a year. This measure incorporates the effects of both mortality and the age distribution.

MODEL LIFE TABLE An expression of typical mortality experience derived from a group of observed *life tables*.

MOVING AVERAGES The successive averaging of two or more adjacent values of a series in order to remove sharp fluctuations.

NATURAL FERTILITY The age pattern of *marital fertility* observed in non-contraceptive populations where reproductive behavior is not affected by the number of children already born.

NET MIGRATION The difference between gross immigration and gross emigration.

NET REPRODUCTION RATE The average number of female children born per woman in a *cohort* subject to a given set of *age-specific fertility rates*, a given set of age-specific mortality rates, and a given *sex ratio at birth*. This rate measures replacement fertility under given conditions of fertility and mortality: it is the ratio of daughters to mothers assuming continuation of the specified conditions of fertility and mortality.

OWN-CHILDREN METHOD A refinement of the *reverse survival* procedure for fertility estimation, whereby estimates of *age-specific fertility rates* for the recent

past are obtained by relating mothers to their own children, using information on relationship and other characteristics available from a census or survey.

PARITY See *children ever born*.

PERIOD FERTILITY The fertility experienced during a particular period of time by women from all relevant birth or marriage *cohorts*; see also *cohort fertility*.

PREGNANCY HISTORY A record of the number and the dates of occurrence of all the pregnancies experienced by a particular woman. The outcome of the pregnancy—live birth, stillbirth, fetal death—is also recorded.

${}_xq_0$ The probability of dying between birth and some exact age x, sometimes also written $q(x)$: q is the probability of dying, 0 is birth, and x is the exact age up to which the probability of dying refers.

RADIX The hypothetical birth cohort of a *life table*. Common values are 1, 1,000, and 100,000.

RATE OF NATURAL INCREASE The difference between the births and deaths occurring during a given period divided by the number of person-years-lived by the population during the same period. This rate, which specifically excludes changes resulting from migration, is the difference between the *crude birth rate* and the *crude death rate*.

RETROSPECTIVE SURVEY A survey that obtains information about demographic events that occurred up to some specific time, generally the time of the survey.

REVERSE SURVIVAL A technique to estimate an earlier population from an observed population, allowing for those members of the population who would have died according to observed or assumed mortality conditions. It is used as a method of estimating fertility by calculating from the observed number of survivors of a given age a the expected number of births that occurred a years earlier. (In situations for which mortality is known or can be reliably estimated, reverse survival can be used to estimate migration.)

ROBUSTNESS A characteristic of estimates that are not greatly affected by deviations from the assumption on which the estimation procedure is based.

SEX RATIO AT BIRTH The number of male births for each female birth, or male births per 100 female births.

SINGULATE MEAN AGE AT MARRIAGE (SMAM) A measure of the mean age at first marriage, derived from a set of proportions of people single at different ages or in different age groups, usually calculated separately for males and females.

SURVIVAL RATIO The probability of dying between one age and another; often computed for age groups, in which case the ratios correspond to those of the person-years-lived function, ${}_nL_x$, of a *life table*.

SYNTHETIC PARITY The average parity calculated for a hypothetical cohort exposed indefinitely to a set of period *age-specific fertility rates*.

TOTAL FERTILITY RATE (TFR) The average number of children that would be born per woman if all women lived to the end of their childbearing years and bore children according to a given set of *age-specific fertility rates*; also referred to as total fertility. It is frequently used to compute the consequence of childbearing at the rates currently observed.

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COMMITTEE ON
POPULATION AND DEMOGRAPHY Report No. 2

Fertility and Mortality Changes in Thailand, 1950–1975

Panel on Thailand
Committee on Population and Demography
Assembly of Behavioral and Social Sciences
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1980

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NOTE: Members of the Committee and its panels and working groups participated in this project in their individual capacities; the listing of their organizational affiliation is for identification purposes only, and the views and designations used in this report are not necessarily those of the organizations mentioned.

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Preface

The Committee on Population and Demography was established in April 1977 by the National Research Council, in response to a request by the Agency for International Development (AID) of the U.S. Department of State. It was widely felt by those concerned that the time was ripe for a detailed review of levels and recent trends of fertility and mortality in the developing world. Although most people in the demographic community agree that mortality has declined in almost all developing countries during the last 30 years, there is uncertainty about more recent changes in mortality in some countries, about current levels of fertility, and about the existence and extent of recent changes in fertility.

In 1963, a Panel on Population Problems of the Committee on Science and Public Policy of the National Academy of Sciences published a report entitled *The Growth of World Population*. The appointment of that panel and the publication of its report were expressions of the concern then felt by scientists, as well as by other informed persons in many countries, about the implications of population trends. At that time, the most consequential trend was the pronounced and long-continued acceleration in the rate of increase of the population of the world, and especially of the population of the poorer countries. It was estimated in 1963 that the annual rate of increase of the global population had reached 2 percent, a rate that, if continued, would cause the total to double every 35 years. The disproportionate contribution of low-income areas to that acceleration was caused by rapid declines in mortality combined with high fertility that

remained almost unchanged: the birth rate was nearly fixed or declined more modestly than the death rate.

Since the earlier report, however, the peak rate of growth in the world's population has apparently been passed. A dramatic decline in the birth rate in almost all the more developed countries has lowered their aggregate annual rate of increase to well below 1 percent, and the peak rate of increase has also apparently been passed in the less-developed parts of the world as a whole. A sharp decline in fertility in many low-income areas has more than offset the generally continued reduction in the death rate, although the rate of population increase remains high in almost all less-developed countries.

The causes of the reductions in fertility—whether they are the effect primarily of such general changes as lowered infant mortality, increasing education, urban rather than rural residence, and improving status of women or of such particular changes as spreading knowledge of and access to efficient methods of contraception or abortion—are strongly debated. There are also divergent views of the appropriate national and international policies on population in the face of these changing trends. The differences in opinion extend to different beliefs and assertions about what the population trends really are in many of the less-developed countries. Because births and deaths are recorded very incompletely in much of Africa, Asia, and Latin America, levels and trends of fertility and mortality must be estimated, and disagreement has arisen in some instances about the most reliable estimates of those levels and trends.

It was to examine these questions that the Committee on Population and Demography was established within the Assembly of Behavioral and Social Sciences of the National Research Council. It was funded for a period of three years by AID under Contract No. AID/pha-C-1161. The Committee has undertaken three major tasks:

1. To evaluate available evidence and prepare estimates of levels and trends of fertility and mortality in selected developing nations;
2. To improve the technologies for estimating fertility and mortality when only incomplete or inadequate data exist (including techniques of data collection);
3. To evaluate the factors determining the changes in birth rates in less-developed nations.

Given the magnitude of these tasks, the Committee decided to concentrate its initial efforts on the first two tasks; it initiated work on the third task in 1979.

The Committee approaches the first task through careful assessment, by

internal and external comparison, and through analysis, by application of the most reliable methods known, of all the data sources available. Each of the country studies therefore consists of the application of a range of methods to a number of data sets. Best estimates of levels and recent trends are then developed on the grounds of their consistency and plausibility and the robustness of the individual methods from which they were derived.

The Committee's second task, refinement of methodology, is seen as a by-product of achieving the first. The application of particular methods to many different data sets from different countries and referring to different time periods will inevitably provide valuable information about the practical functioning of the methods themselves. Particular data sets might also require the development of new methodology or the refinement of existing techniques.

The Committee set three criteria for identifying countries to study in detail: that the country have a population large enough to be important in a world view; that there be some uncertainty about levels and recent trends of fertility or mortality; and that sufficient demographic data be available to warrant a detailed study. After a country has been selected for detailed study, the usual procedure is to set up a panel or working group of experts, both nationals of the country and others knowledgeable about the demography and demographic statistics of the country. The role of these panels and working groups, which generally include at least one Committee member, is to carry out the comparisons and analyses required. A small staff assists the Committee, panels, and working groups in their work.

As of mid-1979, 106 population specialists around the world were members of one or more panels or working groups. This number includes 66 specialists from developing nations. The Committee, the Assembly, and the National Research Council are grateful for the unpaid time and effort these experts have been willing to give.

Each country being studied has a different mix of data sources and different problems with data errors. Therefore, there is no standard pattern for all the reports. However, each report includes a summary of the main findings regarding estimates of fertility and mortality, a description of the data sources available, and a presentation of the analyses that were carried out, classified by type of data analyzed; detailed methodological descriptions are included where necessary in appendixes.

In some of the reports the estimates of fertility and mortality are presented as ranges. The use of a range is deliberate. It indicates that the panel and the Committee are confident that the range includes the true value, but have concluded that the evidence does not warrant selecting a

single figure as best. The range conveys an important aspect (uncertainty) of the estimation. Ideally, in constructing an average for several populations in each of which estimation is presented as a range, an aggregate range should be calculated (as the population-weighted average of the constituents). The user who selects a single figure from the middle of the range does so at the risk of misleading simplification.

This report, on levels and recent trends of fertility and mortality in Thailand, is No. 2 in a series produced by the Committee. The work leading to this report was carried out by the Panel on Thailand, which was established in September 1977 to conduct the required study. The work of the Panel culminated in a workshop held in Pattaya, Thailand, on June 19–23, 1978, and attended by all Panel members plus representatives of interested organizations within Thailand. A number of background papers, some prepared specially for the workshop and others published or intended for publication elsewhere, were distributed to the participants. At the completion of the workshop, the Panel assessed the evidence available and arrived at the conclusions presented in this report.

It should be stressed that this report is not a report on the workshop itself, but is rather a summary of those results regarded by the Panel as being of particular importance or of acceptable reliability. A number of background papers are cited as support for the estimates given, but are not reproduced as a part of the report itself. Complete sets of these papers are being kept at the Institute of Population Studies, Chulalongkorn University, Bangkok; at the Population Survey Division, National Statistical Office, Bangkok; at the Institute of Population and Social Research, Mahidol University, Bangkok; at the Population Division of the Economic and Social Commission for Asia and the Pacific, Bangkok; at the Office of Population Research, Princeton University, U.S.A.; and at the National Academy of Sciences, Washington, D.C., U.S.A.

The Committee's thanks for this study are clearly due to the Panel members, who labored hard and long on the organization and analysis involved in the study. Thanks are also due to the staff of the National Research Council, in particular to David A. Goslin, executive director of the Assembly of Behavioral and Social Sciences, and Eugenia Grohman, editor for the Assembly, for their support, assistance, and advice. All the permanent staff of the Committee have helped in some way with the production of this report, but special thanks are due to Brenda Buchbinder, administrative secretary; to Mary Anne Fitzgerald, research assistant, for carrying out many tedious and repetitive calculations; and to Solveig Padilla, secretary, for coping with the tables.

Our thanks are also due to Arjun Adlakha, International Program of Laboratories for Population Studies; John Fulton, Brown University;

James Spitler, Census Bureau, U.S. Department of Commerce; Vijay Verma, World Fertility Survey; and to all the participants in the workshop held by the Panel, in Thailand in June 1977, for useful comments on the data and methods of analysis used in this report. We are also grateful to the reviewers of early drafts of this report for helpful comments and suggestions, in particular to Judith Blake, University of California, and to Warren Robinson, Pennsylvania State University.

Finally, thanks are also due to the Thailand Ministry of Public Health and National Statistical Office for providing us with previously unpublished data that proved to be of great value to our analysis.

ANSLEY J. COALE, *Chairman*
Committee on Population and Demography

Summary

The application of appropriate analytical techniques to the range of demographic data available for Thailand produces rather consistent estimates of fertility and mortality for various time periods. The estimates of the time trend of fertility are especially consistent, as is shown by Figure 1. In terms of the total fertility rate, the level in the early 1960s was in the range of 6.3–6.6. The level began to decline fairly sharply in the mid-1960s, reaching a level of 5.4–5.8 in 1970. The decline continued through the early 1970s, reaching a level in 1975 of 4.5–4.9. Two sources of estimates, the Survey of Fertility in Thailand (SOFT) and the reverse survival of the 1975 Survey of Population Change (SPC) single-year age distribution, indicate an acceleration of fertility decline in the early 1970s; it is possible, however, that these results are influenced by typical data errors in these sources, and it cannot be concluded with confidence that the rate of decline accelerated in the early 1970s.

The overall fertility decline is largely accounted for by rapid change in the Central and North regions of Thailand, with much slower change in the Northeast and South regions. Urban fertility was probably already declining by 1960 and continued to decline throughout the period; rural fertility, on the other hand, remained constant until the second half of the 1960s, and then began a rapid decline.

The available estimates of mortality, and particularly the estimates of adult mortality, are somewhat less consistent. The estimates of child mortality, using the probability of dying by age 5, ${}_5q_0$, as the index, show reasonable consistency between the direct sources, the Surveys of

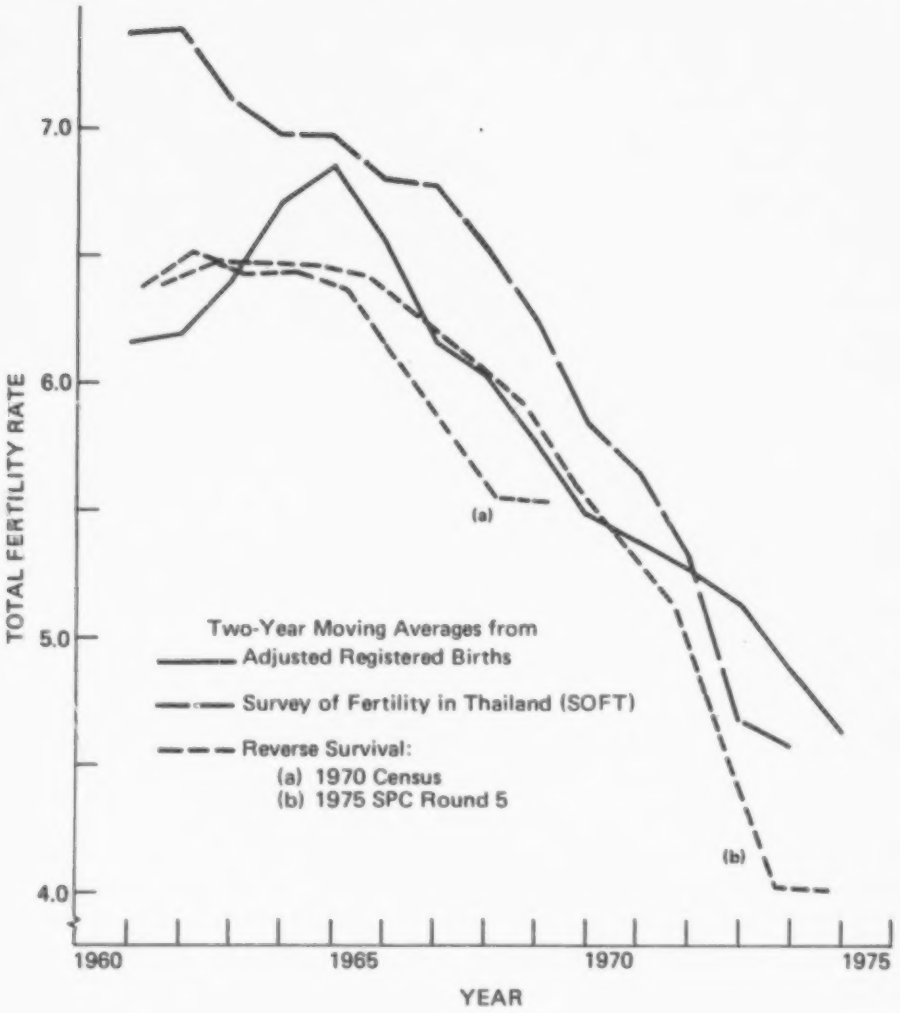

FIGURE 1 Total fertility rates by single calendar years and source of estimate, 1960–1975: Thailand.

Population Change, and the indirect sources, the analysis of data on children ever born and children surviving by age of mother, although the indirect sources indicate in general somewhat lower mortality. All these estimates show a downward mortality trend from the mid-1960s to the mid-1970s, the probability of dying by age 5 declining by some 15 percent over the period. The infant mortality estimates also show a clear but not rapid decline over the period, the infant mortality rate being below 70 per

1,000 by 1975, although these estimates are less reliable than those of ${}_5q_0$. The available estimates of adult mortality are probably the weakest: expectation of life at age 10 from the SPC data shows little change for males and a slight improvement for females between the mid-1960s and the mid-1970s; estimates based on attempts to adjust the death registration figures for the effects of omission show a much higher mortality level, although they also show the level to be declining slowly with time.

In terms of overall mortality, expectation of life at birth probably increased by some two or three years between the mid-1960s and the mid-1970s, reaching about 58 years for males and 64 years for females by the end of the period. The normal female advantage of lower mortality at most ages seems to be particularly marked in Thailand. Regional variations of mortality are fairly pronounced, with the Central region having the lowest mortality, followed by the South, followed by the Northeast and the North, the last having a slightly heavier mortality, at least in childhood. Urban areas seem to have lower mortality than rural areas, as is to be expected.

The estimates of total fertility and child and adult mortality presented above can be used to derive the natural rate of population increase through the calculation of crude birth and death rates. The ranges of total fertility can be converted into ranges of crude birth rates, the results being 43–46 births per 1,000 population for the early 1960s, 36–38 by 1970, and 32–36 by 1975. The decline in the crude death rate is much more gradual, from about 10–11 in the mid-1960s to about 8–9 in the mid-1970s. The derived growth rates range from 3.2 to 3.4 percent in the early 1960s, falling to between 2.6 and 2.9 percent by 1970, and continuing to fall to between 2.3 and 2.6 percent by 1975.

The Panel recognizes that for many purposes a single figure is preferable to a range. However, in view of the uncertainties that remain despite the considerable consistency shown by the various estimates available to the Panel, it is felt that the only responsible procedure is to give the ranges within which the Panel believes the true values lie.

Fertility and Mortality Changes in Thailand, 1950–1975

INTRODUCTION

Thailand meets all the criteria set by the Committee on Population and Demography for inclusion among those countries to be studied in detail. The population recorded by the 1970 population census was over 34 million, several surveys have indicated a fertility decline in recent years, though the extent of this decline has been the subject of dispute, and demographic statistics from a variety of sources are available covering a considerable period of time. The charge of the Panel was to estimate levels and recent trends of fertility and mortality in Thailand, taking into consideration all the available sources of information relevant to the estimation of these demographic parameters, and to investigate regional or socioeconomic differentials insofar as these have a bearing on the plausibility of the findings of the study. The work of the Panel therefore consisted of a critical examination of existing studies and further analysis of existing data where recently developed or improved analytical methodologies would justify it.

Thailand has a number of sources of demographic data, and it has therefore been possible to apply a wide range of techniques of demographic analysis. Following a brief section describing the data sources available, the main body of this report consists of a description of the results obtained by applying the full range of analytical techniques regarded as relevant to those data sources. The presentation of these analytical results is organized by type of data source, so that, for example, all methods based

primarily upon age distributions are presented in one section. In the final section, estimates of fertility and mortality based on different data sources are brought together and compared for consistency and the conclusions are presented.

DATA SOURCES

The situation of Thailand is particularly satisfactory with respect to the availability of demographic data; these are generally of high quality, of a wide variety of types, and cover a reasonably long time period. Registration of births and deaths, though incomplete, provides a continuous series of data from early in the century to 1975, though no use is made here of information for periods earlier than 1937. Population censuses, of varying demographic content, have been held since 1911, although only the censuses of 1937, 1947, 1960, and 1970 are considered in this study. Two surveys of a dual-record type, the Surveys of Population Change (SPC), have been conducted to estimate fertility and mortality parameters and the completeness of registration, the first between 1964 and 1967 and the second between 1974 and 1976. Two rounds of a panel-type survey, the Longitudinal Study of Economic, Social, and Demographic Change (LS), collecting information on recent fertility and related factors, were conducted in 1969–1970 and 1972–1973. In 1975 the Survey of Fertility in Thailand (SOFT) was conducted as part of the World Fertility Survey; it collected complete birth histories and other relevant information from a sample of ever-married women. Table 1 summarizes these data sources by the evidence available from them relevant to this study.

Additional evidence of an indirect nature relevant to the estimation of fertility is available from the statistics of new acceptors of contraceptive methods compiled by the National Family Planning Program, as well as from local studies such as the Northern Thailand Fertility Study; these local studies are not taken into consideration in this report.

RESULTS

POPULATION AGE DISTRIBUTIONS

Problems Associated with Age Reporting in Thailand

Age reporting in Thailand is good in relation to that in most other countries in the world. Single-year age distributions show only minimal age heaping (Arnold et al. 1977). Even the rural and less-educated segments of the population appear to know both their age and their year or

TABLE 1 Data Sources by Evidence Available: Thailand

Type of Evidence	Censuses			Surveys of Population Change		Longitudinal Surveys		Survey of Fertility in Thailand, 1975	Vital Registration	
	1947	1960	1970	1964-1967	1974-1976	1969-1970	1972-1973		1937-1959	1960-1975
Age/sex distribution										
Five-year groups	X	X	X	X	X	X	X	X		
Single years		X	X		X			X		
Own-children tabulation			X							
Registered births										
By age group of mother									X	X
By birth order										X
Registered deaths										
By sex and age									X	X
Children ever born										
By age of mother		X	X		X	X	X	X		
Children surviving										
By age of mother			X		X			X		
Fertility histories						X	X[a]	X		
Contraceptive-use data						X	X	X		

[a]Full fertility histories available for new respondents only; former respondents asked only about births during last three years.

date of birth since the latter is important for astrological reasons. However, as reported in some detail in the paper by Chamratrithirong et al. (1978), there is substantial evidence of a tendency to state age at next birthday in preference to age at last birthday in response to a direct question about age. Although the extent to which this practice occurs has not yet been determined, it seems clear that at any given single age, a substantial proportion of respondents state their age at next birthday as opposed to age at last birthday; there is some evidence that the tendency is to round age to that at the nearest birthday.

In the absence of more definitive evidence, most adjustments of age data to allow for this tendency in the papers presented in the Panel's workshop assume that in stating age directly, half of the respondents round age up to the next birthday whereas half report age at last birthday. The problem is particularly important for analyses that use sources that tabulate age on different bases. Persons who give age directly will, according to our assumption, be reported as being on average about half a year older than if their age had been computed from birth dates. The sources used in the analyses presented to the workshop can be divided according to the way age was determined:

Sources Based on Age as Reported	Sources Based on Age Calculated from Birth Date
1947 and 1960 censuses	1970 census
Vital registration	SOFT
Family planning acceptor statistics	LS rounds one and two
	Baseline surveys and surveyed events in SPC

It should be noted that some previously published results for the rural round one of the Longitudinal Survey were tabulated on the basis of stated age.

A special problem regarding age reporting for infants and young children exists because their ages are often stated by respondents in terms of weeks or months instead of years. In such cases, one can expect rounding to occur in terms of weeks or months; this rounding will have a different and smaller effect in terms of years of age than will rounding for adults, for whom age is reported in units of years. The available evidence is unfortunately even less adequate for arriving at a definite judgment about how much of an adjustment is required to allow for this effect on age reporting for infants and young children. Several formulas were used in

the analyses presented to the workshop for adjusting distributions of five-year age groups to allow for the tendency to state age at next birthday (see Chamratrithirong et al. 1978, Hill 1978).

Stable Population Analysis

A population exposed for a long period to constant fertility and mortality rates establishes a constant age structure typical of the rates; a population with such an unchanging age structure is referred to as a stable population. The constant age structure contains information about the underlying fertility and mortality rates, and it can be used to estimate them given some additional information such as the rate of natural increase or the level of childhood mortality.

Leoprapai and Wanglee (1978) analyzed the male age structures from the 1960 and the 1970 censuses, using rates of population growth computed for the 1947–1960 and 1960–1970 intercensal periods. In justifying the application of the method, they note that Thailand experienced very low levels of net international migration for a long period prior to the two censuses, that mortality had been declining for a considerable period prior to 1960, the decline continuing to 1970, and that fertility had probably started to decline prior to 1970. A steady, gradual mortality decline has a rather modest impact on population age structure, though it would tend to imply spuriously lower fertility for proportions over higher and higher ages. Fertility decline, on the other hand, has a more immediate and substantial impact on the population age structure, requiring that the results be interpreted with caution. A further problem is encountered with the 1960 and 1970 age distributions, because the former was distorted by the form of the age question, and the 1970 census seems to have been more seriously affected by underenumeration than the 1960 census. The age distributions used in the Leoprapai and Wanglee analysis were the adjusted ones developed for both years (Arnold and Phananiramai 1975), the results therefore being to some small extent dependent on the adjustment procedure.

Table 2 shows the estimates obtained, in terms of crude birth rate and crude death rate. Table 2 also shows estimates of the total fertility rate implied by the birth rate for both sexes combined: this derived total fertility rate was obtained by using the age pattern of fertility of registered births in the years prior to the censuses and scaling the registered rates to agree with the estimated birth rate. The results show a relatively high birth rate of 46 prior to 1960 and a somewhat lower rate of 42 prior to 1970, though the latter estimate needs to be interpreted with caution in view of the fertility decline then under way. A sharp decline in the crude death

TABLE 2 Stable Population Analysis, 1960 and 1970 Censuses: Thailand

	Estimates		
Census	CBR	TFR[a]	CDR
1960	45.9	6.50	15.2
1970	42.3	6.26	10.3

[a]Estimated equivalent derived from CBR.

SOURCE: Leoprapai and Wanglee (1978).

rate, from 15 to 10 per 1,000, is shown; the latter figure is satisfactorily consistent with the mid-decade estimate from the 1964–1965 SPC.

Reverse Survival

If independent estimates of child mortality are available, the age distribution of children can be used to obtain estimates of aggregate fertility not dependent on the assumption of stability. Reverse survival is applied to the enumerated population in an age group, using the child mortality estimates, to obtain the number of births in a period for which the enumerated population represents the survivors; the period depends on the age group used, being, for example, the five years prior to the census in the case of the census age group 0–4. The birth rate can then be obtained by dividing the estimated number of births by an estimate of the total person-years lived by the population during the period, this in turn being obtained as the mid-period population by applying an observed rate of natural increase or, more laboriously, by applying reverse survival to the entire population. The method can be applied to five-year age groups, dampening the effects of age heaping, or to single-year groups, showing wider variations but being more revealing of both errors and recent trends.

Leoprapai (1978) applied this method to the population of each sex under age 5 in the adjusted age distributions from the 1960 and 1970 censuses (Arnold and Phananiramai 1975), using mortality figures from the 1964–1965 and 1974–1976 Surveys of Population Change. The results depend to some extent on the adjustments made to the census age distributions. Additional calculations were circulated at the Panel's workshop, applying the reverse survival technique to the enumerated populations aged 0–4 and 5–9 in 1960, 1964–1965, 1970, and 1974, and also to the 1960 population adjusted for half a year by subtracting half those aged 5 from the age group 5–9, adding them to the age group 0–4,

TABLE 3 Fertility Estimation from Reverse Survival to Recorded and Adjusted Age Distributions, 1960-1975: Thailand

	Period to Which Estimate Refers				
Source of Age Information	1950-1954	1955-59	1960-1964	1965-1969	1970-1974
1960 census, unadjusted	44.2	40.0			
1960 census					
Adjusted[a]		43.3			
Adjusted[b]	43.3	44.1			
1964-1965 SPC, midyear		42.8	43.3		
1970 census, unadjusted			44.8	40.7	
1970 census, adjusted[a]				41.5	
1974-1975 SPC, round one				41.5	33.2

[a] Adjustments as shown in Arnold and Phananiramai (1975).
[b] Adjusted for half-year age error.

SOURCE: Leoprapai (1978).

and adding half those aged 10 to the age group 5–9. The birth rates obtained for all these alternatives, for periods from 1950–1954 to 1970–1974, are shown in Table 3.

In general, there are two or more aggregate fertility measures for each five-year period, and the agreement between the estimates, based upon independently collected age distributions, is encouraging. The most obvious disagreement is for the period 1955–1959, for which the unadjusted 1960 census age distribution gives a substantially lower estimate of fertility than either the adjusted age distribution or the 1964–1965 SPC age distribution. This discrepancy is consistent with the problem discussed above concerning the form of the 1960 age question. The picture that emerges from this analysis is of approximately constant fertility up to the 1960–1964 period, a drop of 5 percent or so in the 1965–1969 period, and a fall of about 20 percent in the 1970–1974 period.

Single-year age distributions are available from the 1960 census, the 1970 census, and round five (1975) of the second SPC. The latter two sources are of particular interest, since they can provide overlapping year-by-year estimates of aggregate fertility throughout the 1960s. The mortality rates required for application of reverse survival of the two populations were obtained by interpolating between the life tables from the two Surveys of Population Change and by extrapolating to 1960 the observed mortality trend between them. The crude birth rates (by sex) and derived total fertility rates are shown for each year in Table 4.

TABLE 4 Birth Rates and Total Fertility Rates for Single Years, 1960-1975, Obtained by Reverse Survival: Thailand

	Male Birth Rate		Female Birth Rate		Derived Total Fertility Rate	
Year[a]	1975 SPC	1970 Census	1975 SPC	1970 Census	1975 SPC	1970 Census
1975	30.5		28.6		4.11	
1974	29.0		26.2		3.90	
1973	30.3		27.8		4.16	
1972	35.1		33.0		4.96	
1971	36.4		35.2		5.30	
1970	38.8		34.9		5.45	
1969	41.1	38.8	36.5	37.3	5.76	5.63
1968	42.0	37.9	40.0	35.6	6.08	5.45
1967	41.4	39.1	41.0	37.0	6.12	5.64
1966	44.3	41.3	41.4	39.2	6.37	5.97
1965	45.0	42.8	42.6	40.3	6.46	6.18
1964	44.8	45.8	43.6	43.3	6.45	6.56
1963	46.3	44.6	43.6	41.9	6.49	6.31
1962	45.9	46.7	44.5	43.6	6.47	6.52
1961	45.0	47.2	43.9	44.1	6.30	6.52
1960		45.6		42.5		6.23

[a]The date of round five of the SPC can be taken as August 1975 and that of the 1970 census as April 1, 1970. Estimates for 1975 (and other years) from the SPC are thus really for the period August 1974 to August 1975; estimates for 1969 (and other years) from the census are really for the period April 1969 to March 1970.

SOURCE: Hill (1978).

For the years for which the two series overlap, the agreement is impressive between 1960 and 1964, but after 1964, the estimates based on the 1970 age distribution are lower than those based on the 1975 age distribution, probably as a result of age misreporting or omission of young children. Similar biases probably affect the estimates from the 1975 age distribution based on children aged 0, 1, 2, and 3, all of which are suspiciously low. This analysis confirms that aggregate fertility was more or less constant to 1965, after which an accelerating decline began. Though estimates based on young children cannot be relied upon, the estimates from the 1975 age distribution based on children aged 4 and older (those born in 1971 and earlier) look reasonable and agree closely with other series.

Own Children

The own-children estimation technique is a form of reverse survival procedure in which children living in the same household as their mother are matched with the mother by the use of relationship to head of household codes and other information (Cho 1973). Measures of aggregate

fertility obtained from the own-children estimation procedure depend on the age distribution of the children and on the mortality assumptions employed; they are thus neither more nor less accurate than those obtained by the conventional reverse survival technique. However, the relation of children by age to their mothers by age yields additional information, not available from the conventional reverse survival technique, about the age pattern of fertility.

The method has been applied to the 1970 census (Retherford and Cho 1978) by using a special own-children tabulation from the census to relate children to their mothers and adjusting the enumerated population for the underenumeration levels estimated by Arnold and Phananiramai (1975). It should be noted that with the own-children method, the age patterns of fertility depend almost entirely on the own-children tabulation, which links mothers to children, whereas the measures of aggregate fertility depend almost entirely on the number of children of each age, that is, on the age distribution under 10. In the case of Thailand in 1970, the adjusted age distribution used in the own-children analysis was obtained from annual registered births and child deaths between 1960 and 1969, combined with the 1964–1965 SPC estimate of the completeness of birth and death registration. The age pattern estimates are therefore dependent almost entirely on 1970 census information, whereas the estimates of aggregate levels depend on vital registration data and evidence concerning their completeness.

Table 5 shows age-specific and total fertility rates estimated by the own-children method for 1960–1964 and 1965–1969. The age patterns of fertility agree rather well with those obtained from other sources; the level of fertility is approximately 5 percent lower in the second half of the decade than in the first, in close agreement with the results of both the stable population and the reverse survival methods.

Completeness of Census Enumeration

Table 6 shows the total population by sex enumerated by the censuses of 1947, 1960, and 1970, together with the average growth rates implied for the intercensal periods. The growth rate for the period between 1960 and 1970 is substantially lower, at 2.7 percent, than that for the period between 1947 and 1960, 3.2 percent. Since mortality fell between the earlier and later periods (see below), the only factors that could account for the lower growth rate in the later period are a sharp decline in fertility, changes in net migration, or differential completeness of census enumeration.

Net international migration seems to have been negligible in the case of

TABLE 5 Estimates of Age-Specific and Aggregate Fertility Obtained from Own-Children Analysis of 1970 Census: Thailand

	Period	
Age Group	1960-1964	1965-1969
15-19	.086	.089
20-24	.274	.267
25-29	.313	.299
30-34	.281	.260
35-39	.215	.206
40-44	.106	.100
45-49	.020	.019
Total Fertility	6.48	6.19

SOURCE: Retherford and Cho (1978).

Thailand for the period under consideration, and although fertility will be shown to have been falling by the end of the later intercensal period, the fall would have been too small and too late to have caused such a major decline in the growth rate. The rate of natural increase estimated by the SPC for 1964–1965 was 3.1 percent. The low growth rate implied between 1960 and 1970 was probably largely the result of relative underenumeration in 1970. A comparison of cohort intercensal survival and cohort registered deaths (Preston and Hill 1980) leads to estimates of the extent of this relative underenumeration of 5.1 percent for males and 4.0 percent for females (Hill 1978). Estimates of similar magnitude given by Arnold and Wanglee (1975) and Fulton (1975), though obtained by different methodology, confirm the general level of these results. Population figures for 1970 have been adjusted to allow for these estimates of underenumeration in all subsequent methods of analysis requiring population denominators.

TABLE 6 Enumerated Population by Sex, 1948, 1960, and 1970, and Implied Intercensal Growth Rates: Thailand

Population and Growth Rate	Males	Females	Total
1947 population (thousands)	8,722	8,721	17,443
Intercensal growth rate (percent)	3.17	3.14	3.16
1960 population (thousands)	13,154	13,104	26,258
Intercensal growth rate (percent)	2.66	2.78	2.72
1970 population (thousands)	17,124	17,274	34,397

COMPLETENESS OF VITAL REGISTRATION

A problem exists with the use of vital registration data in Thailand, and it needs to be described before methods for estimating the completeness of registration are considered. In the vital registration system (described in Thailand Ministry of Public Health 1978b), the Ministry of the Interior is responsible for the registration system, but detailed tabulations of, for instance, births by age of mother or birth order, are prepared by the Health Information Centre of the Ministry of Public Health. These tabulations are based on event summaries prepared by the provincial health centers from summaries prepared at the district level. The Ministry of the Interior also receives information about the number of births and deaths, transmitted from the district administration to the provincial administration and then to the Ministry. Since 1967 the number of events recorded annually by each Ministry has been different, and the published statistics have been obtained by applying Ministry of the Interior totals to Ministry of Public Health classifications of events by characteristics. In the following analysis of the completeness of birth registration, totals obtained by Tieng Pardthaisong from Ministry of Public Health records have been used to maintain consistency with the totals obtained prior to 1967; these totals, shown by Hill (1978), are typically around 10 percent lower than published totals. Since the completeness of registration is estimated by comparison with independently gathered information, the overall level is not of great importance, though discontinuities in the series may distort the results.

Registered Births Compared with Average Number of Children Ever Born

The completeness of birth registration may be estimated through comparison for successive age groups of women of registered fertility rates with the average number of children ever born, obtained from a census or survey. In the original Brass procedure (Brass et al. 1968), suitable only for situations of constant fertility, age-specific fertility rates obtained from registered births in a given year are cumulated and interpolated for comparison, age group by age group, with information on average parity obtained by a census or survey for the same year. Assuming that the proportion of births that are registered is constant by age group and that younger women report their lifetime fertility accurately, the ratios of average parity to cumulated current fertility, often called P/F ratios, for women aged 20–24 and 25–29 provide indicators of the completeness of registration. Fertility must be constant for the method to work, for

otherwise cumulated current fertility and retrospective lifetime fertility would not be theoretically equal. The only source of information on children ever born that meets this condition is the 1960 census, so only one application of the original technique has been made. The completeness of registration estimated for 1960, shown in Table 7, is 76 percent; when the observed age-specific fertility rates are adjusted for this level of completeness, the total fertility rate estimated for 1960 is 6.5.

Two developments of the original technique are suitable for use under conditions of changing fertility. If information is available on average parity from two surveys five or ten years apart, synthetic parity distributions can be calculated from the parity increments of successive cohorts over the intersurvey period (Hill 1978). This synthetic parity distribution can then be compared with cumulated age-specific fertility rates obtained from registered births and person-years lived over the same period.

This method was applied to two periods: 1960–1969, using information on children ever born from the two censuses; and 1970–1974, using information on children ever born from the 1970 census and an average of the children ever born reported by the 1974 and 1975 SPC's. The 1970 and 1975 parity distributions were adjusted to represent age groups half a year younger than reported, to be on a common age basis with the 1960 census and vital registration data, and the 1974 and 1975 parity distributions from the SPC were averaged in order to approximate the parity distribution applicable exactly five years after the census date. The estimates of birth registration completeness, shown in Table 7, are 81 percent for 1960–1969 and 82 percent for 1970–1974. Adjusting the observed fertility rates by these amounts gives estimates of average total fertility for the two periods of 6.2 and 4.9, respectively.

The second development of the original Brass procedure is more complicated, at least in application. Age-specific fertility rates for five-year age groups are calculated from registered births for each calendar year, and the rates are then split up into rates for single-year age groups (Hill 1978). Given that average parity by five-year groups is available for some point from a census or a survey, the single-year rates experienced in all previous years by each cohort are cumulated from the start of childbearing to the time of the census or survey, and the sum is compared with the recorded parity to provide a measure of average completeness of registration. If information is available for two points five or ten years apart, the cumulation may add on to the parities reported at the earlier point, in which case the ratio of the cumulated rates to the recorded cohort parity increment provides an indication of the completeness of registration during the period between the two surveys. The lifetime cumulation can be

TABLE 7 Estimates of Completeness of Vital Registration: Thailand

	Estimate of Completeness of Registration of Births				Estimate of Completeness of Registration of Deaths			
			P/F Ratios[b]		SPC[a]			
Period	SPC[a]	Cohort Cumulation[b]	1960 Parity	Intersurvey Synthetic Parity	All Ages	Over Age 10	Cohort Attenuation[b]	Growth Balance[c]
1960 or before		.701	.759					.656[d]
1960-1969		.784		.809			.810[e]	.656[d]
1964-1965	.844				.625	.708		
1964-1967	.715				.500	.574		
1970-1974		.797		.818				
1974-1976	.711				.592	.719		

[a]Thailand National Statistical Office, *Reports on Surveys of Population Change.*
[b]Hill (1978).
[c]Rungpitarangsi (1974).
[d]Completeness of adult death registration (over age 10).
[e]Completeness of death registration over age 5 on average.

applied up to 1960, 1970, and 1975, and the intersurvey cumulation can be applied between 1960 and 1970 and between 1970 and 1975. Summarized results, shown in column 3 of Table 7, give an estimate of completeness of 70 percent for the period up to 1960, 78 percent for 1960–1969, and 80 percent for 1970–1974, suggesting that although registration was improving in the 1950s and early 1960s, the improvement did not continue into the late 1960s and early 1970s.

Dual Record System Estimates of Completeness of Birth Registration

Other estimates of the completeness of registration are available from the two Surveys of Population Change. The matching of events recorded by the vital registration system with those recorded by a regular multiround survey provides a method for estimating the number of events missed by both systems and hence the total number of events. The ratio of registered events to total events provides a measure of registration completeness. Such estimates are available from the first year of the first SPC (1964–1965), all three years of the first SPC (1964–1967) and both years of the second SPC (1974–1976).

The estimates, shown in Table 7, show a rather large difference in completeness between the first year and the three years of the first SPC (the three-year figures are thought to be less reliable and are generally not used), and a substantial decline in completeness from the first year of the first SPC to the two years of the second SPC. None of the estimates of completeness agree well with those obtained by comparisons with parity data, the first year of the first SPC giving higher completeness and the other two periods showing lower completeness.

Completeness of Adult Death Registration Using the Growth Balance Method and Intercensal Survival

Rungpitarangsi (1974) describes an ingenious method for estimating the completeness of adult death registration. Finding that intercensal survival between the censuses of 1937, 1947, 1960, and 1970 gave implausible mortality estimates, probably for reasons of varying enumeration completeness, Rungpitarangsi applied the Brass growth balance method (Brass 1975) to registered deaths in each census year in order to estimate the completeness of adult death registration. The estimates obtained were then averaged, by sex, and applied as a correction factor to registered deaths of those aged 5 and over in each intercensal interval to estimate the correct number of deaths. Taking the 1960 census enumeration as the most complete, the adjusted intercensal deaths were used to estimate the relative

completenesses of enumeration of the other censuses, the adjusted populations of which were then used to provide denominators for the calculation of intercensal life tables from age 5 using adjusted intercensal deaths as numerators. The life tables were completed by splicing on suitable model life tables to represent mortality up to age 5. However, since the method essentially estimates completeness of registration of deaths after childhood, it is estimates of completeness of registration of these deaths that are shown in Table 7. With reference to this method, it should be noted that if mortality is declining, completeness of registration will tend to be underestimated. The registration of adult deaths is estimated to be about 66 percent complete, both for the period prior to 1960 and for the period from 1960 to 1970.

Dual Record System Estimates of Completeness of Death Registration

As in the case of birth registration, the Surveys of Population Change provide estimates of the completeness of death registration for 1964–1965, 1964–1967, and 1974–1976. These completeness estimates can be calculated by age group, and for comparison purposes, Table 7 shows the estimates of completeness of registration of all deaths and of deaths over age 10. The estimates of completeness, both overall and over age 5 or 10, are reasonably consistent, with the exception of that obtained from the cohort attenuation method (Hill 1978). It is difficult, however, to draw firm conclusions concerning the completeness of death registration from these estimates, beyond saying that completeness is probably around 60 percent, that it is higher for adult than child deaths, and that there is no evidence of any continuing trend in completeness over time.

CHILDREN EVER BORN DATA FROM TWO SURVEYS

If information on children ever born is available from two censuses or surveys five or ten years apart, the age-specific fertility schedule for the intersurvey period may be estimated from the parity increments of successive cohorts (National Research Council 1980). Table 8 shows the age-specific fertility rates for 1960–1969 and 1970–1974 estimated in this way, after adjustment of the 1960 parity figures for the half-year age shift (Hill 1978). The results are affected if children are omitted from the reports of older women, and there is some reason to suppose that this may have happened in 1960, and to a lesser extent in 1970, although the overall effect is probably small. The total fertility rate estimated by this method is 6.2 for 1960–1969, close to the adjusted registration estimates and very close to the SPC mid-decade estimates. For 1970–1974 the estimate of total

TABLE 8 Age-Specific Fertility Rates Estimated from Intersurvey Cohort Parity Increment: Thailand

	Period	
Age Group	1960-1970	1970-1975[a]
15-19	.080	.076
20-24	.253	.213
25-29	.301	.235
30-34	.272	.202
35-39	.208	.149
40-44	.101	.109
45-49	.019	.025
Total Fertility	6.17	5.04

[a]Average number of children ever born by age group of mother in 1975 was obtained as a weighted average of results from rounds one and five of the second SPC, to approximate a date of April 1, 1975.

SOURCE: Hill (1978).

fertility from this method is 5.0, almost exactly the same as the adjusted registration figure. The agreement is not surprising, since the estimates of completeness of birth registration depend on the same parity data as the cohort parity increment method.

INDIRECT ESTIMATES OF INFANT AND CHILD MORTALITY

Both infant mortality and child mortality have been estimated directly by the Surveys of Population Change, and the results are included in the summary table of mortality estimates in the final summary section of this report. A series of indirect estimates of child mortality is also available, based on proportions dead among children ever born as reported in the 1970 census, the 1974–1976 SPC, and the SOFT (see Knodel and Chamratrithirong 1978 and additional tabulations prepared for the workshop).

The proportion dead among children ever born to women of a given age depends on the age pattern of childbearing, which determines the age distribution of the children ever born, and the mortality risks to which they were exposed. If the age pattern of childbearing can be estimated and an age pattern of child mortality can be assumed, proportions dead among children ever born may be converted into estimates of probabilities of dying by exact ages of childhood (Brass 1964).

The procedure used here was developed by Trussell (National Research Council 1980), who studied the relationship between ratios of probabilities of dying to proportions dead among children ever born and indicators, in this case average parity ratios, of the age pattern of childbearing, using linear regression on a large number of computer-generated cases based on demographic models. The relationships used here were based on the subset of model cases generated by using the Coale and Demeny (1966) "North" age pattern of child mortality. (A full discussion of this technique will be found in National Research Council 1980.) Indirect estimates derived from the reported proportion dead among children ever born will underestimate child mortality to some extent if women underreport children who died to a greater extent than children who survived. In general, the results from applying the indirect estimation technique to data from Thailand are in reasonable agreement with the direct estimates of child mortality obtained by the dual record system approach of the SPC's, although the indirect estimates are slightly lower in most cases.

Table 9 shows the indirect estimates of the probability of dying by exact ages 2, 3, and 5 based on data from the 1970 census, rounds one and five of the 1974–1976 SPC, and the SOFT. The table also shows estimates of the time to which each estimate refers: t^* is the number of years prior to the date of the census or survey to which the estimates refer. The indirect estimates of child mortality are reasonably consistent with one another. Round one and round five of the second SPC give very similar estimates, though round five shows slightly higher average mortality. The estimates from the 1970 census, referring roughly to a period five years earlier, show a substantially higher mortality level. The results from the SOFT, taken between the two rounds of the second SPC and therefore referring to a similar time period, are consistently higher, perhaps indicating lower omission of dead children using the pregnancy history question. The general picture, however, is of moderate child mortality for a developing country and of a gradual decline in the level of mortality from the mid-1960s to the early 1970s.

The estimates of child mortality in the form of estimates of ${}_2q_0$, ${}_3q_0$, and ${}_5q_0$ are derived from the proportions dead among children ever born to women aged 20–24, 25–29, and 30–34, respectively; each refers to a different number of years prior to the date on which the information was collected. It is possible to combine these three estimates into a single summary measure of child mortality by averaging the levels of mortality implied by each in some system of model life tables; any single index of child mortality corresponding to the average level can then be derived from the same model life tables. This procedure was followed using the "North" family from the Coale and Demeny (1966) regional model life

TABLE 9 Indirect Estimates of Child Mortality from Proportions Dead Among Children Ever Born, Using the Trussell Technique: Thailand

Source of Estimate	$_2q_0$	t^*	$_3q_0$	t^*	$_5q_0$	t^*
1970 census	.0753	2.2	.0967	3.8	.1223	6.0
1974 SPC (round one)	.0667	2.3	.0791	3.8	.1064	5.7
1975 SPC (round five)	.0716	2.3	.0769	3.9	.1043	5.8
1975 SOFT	.0786	2.3	.0883	4.0	.1169	5.8

Note: t^* indicates the estimated number of years before the census or survey to which the child mortality estimate refers.

SOURCE: 1970 and 1974 results from Knodel and Chamratrighirong (1978) and additional calculations for 1975 results.

tables, and the summary value of $_5q_0$ was found for each case (see Table 10). The time before the survey to which each average estimate referred was calculated as the average of the three times found for the separate estimates of mortality derived from each age group of women.

In addition to the estimates of child mortality obtained from the indirect methods, time trends in infant mortality ($_1q_0$) can also be derived. The Trussell technique does not directly give estimates of $_1q_0$, but each estimate of the probability of dying by age n, $_nq_0$, corresponds to a mortality level in the "North" model life table system, and the infant mortality rate for that level can be found. The accuracy of these estimates of infant mortality can be affected not only by biases in reporting of children ever born and children surviving, which affect all the indirect estimates, but also by the appropriateness of the fit between the actual age pattern of child mortality and the age pattern built into the "North" model life tables that were used in the determination of infant mortality. The time series of these indirect estimates of infant mortality are presented in the summary table on mortality included in the final summary section of this report.

FERTILITY ESTIMATES FROM BIRTH HISTORIES

Estimates of recent levels and trends in Thai fertility are available from birth histories collected by several national sample surveys. Two approaches have been used. In the first approach, marital fertility rates for the year or two years prior to the time of the survey have been calculated on the basis of the births recorded during those periods in the birth history. It is possible to determine trends in marital fertility in this way by comparing the results obtained from the various rounds of the LS and the SOFT. The second approach uses a single set of birth histories from a

TABLE 10 Mortality Indicators by Period: Thailand

Indicator/Source	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Child Mortality														
${}_5q_0$ (probability of dying by exact age 5)														
SPC life tables		.1226											.0969	
Indirect:[a]														
1970 census				.1097										
1974 SPC								.0938						
1975 SPC									.0944					
1975 SOFT									.1057					
Infant mortality rate														
SPC life tables		86											68	
Indirect:[b]														
1970 census	77		71		63									
1974 SPC						68		59	56					
1975 SPC							67		58	60				
1975 SOFT							74		66	65				

Indicator/Source	1935	1940	1945	1950	1955	1960	1965	1970	1975
Adult Mortality									
Expectation of life at age 10, ${}_{10}\mathring{e}_{10}$									
SPC life tables, males							55.7		55.7
Growth balance,[c] males	42.2		42.5			52.1		53.1	
SPC life tables, females							59.2		60.7
Growth balance,[c] females	44.6		45.3			55.4		56.7	
All Mortality									
Expectation of life at birth, ${}_0\mathring{e}_0$									
SPC life tables, males							56.3		58.0
SPC life tables, females							60.6		63.8

[a] ${}_5q_0$ of "North" model life table level with average level of results shown in Table 9.
[b] ${}_1q_0$ of "North" model life table of level determined by each estimate in Table 9.
[c] From Rungpitarangsi (1974).

particular survey and calculates retrospectively annual age-specific fertility rates based on these data. This has been done for the SOFT, fertility rates having been calculated retrospectively to 1960.

Marital fertility rates based on births occurring one year or two years prior to each survey are shown in Table 11. Since the age distributions of currently married women were substantially different in the surveys involved, it is necessary to standardize the summary measure of marital fertility for age. Both unstandardized and standardized rates are shown. Comparison of the rates based on a one-year and a two-year period prior to the survey reveals a consistent difference. When the age-specific marital fertility rates are converted into age-specific fertility rates and total fertility rates are calculated from the latter rates (results not shown), the two-year rates are too low in comparison with other available estimates of fertility. It seems clear that the different results obtained when calculating fertility rates for a one-year rather than a two-year period prior to the survey arise from complicated distortions of the time scale on which women report the birth of their children, a problem observed not infrequently when using data obtained from fertility histories in developing countries.

Regardless of whether one- or two-year rates are used, however, a clear trend towards declining marital fertility is evident from the standardized marital fertility rates. The one-year rates for the whole country indicate that marital fertility declined by 21 percent from the time shortly before the first rounds of the Longitudinal Survey in 1969 and 1970 to the time shortly before the SOFT in 1975. The equivalent decline for the two-year rates is 16 percent. It should be noted that the one- and two-year rates were not calculated in precisely the same manner; however, the differences should have only trivial effects.

Retrospective estimates of the total fertility rate based on birth histories have been published in *SOFT: Country Report, Volume 1* (Institute of Population Studies and National Statistical Office 1977). Since the publication of these results, several revisions have been made. A comparison of the previously published results with the revised results is shown in Table 12. Two types of revisions or adjustments account for the differences. A new way of calculating the fertility rates for five-year age groups for which only incomplete data were available was used to obtain the first set of revised estimates, shown in the second column in Table 12. It was noticed, however, that the proportions of women ever married by age indicated from the household schedules collected in the SOFT were substantially lower than the proportions of women ever married by age indicated by either the 1970 census or the 1975 SPC. The latter two sources agree quite closely with each other, suggesting that the SOFT results are probably not representative. The age-specific fertility rates derived from

TABLE 11 Births During One Year and During Two Years Prior to Interview per 1,000 Married Women 15-49, Unstandardized and Standardized for Age Based on Sample Surveys: Thailand

Place of Residence of Respondent and Year of Interview and Survey Source	Rates Based on Births Occurring During One Year Prior to Survey		Rates Based on Births Occurring During Two Years Prior to Survey		Ratio of One-Year to Two-Year Rates, Unstandardized
	Unstandardized	Standardized	Unstandardized	Standardized	
Rural					
1969 LSI	277	298	234	258	1.18
1972 LSII	239	260	207	224	1.15
1975 SOFT	223	227	210	211	1.06
Urban					
1970 LSI	192	209	175	185	1.10
1973 LSII	180	193	164	179	1.10
1975 SOFT	188	193	175	179	1.07
Kingdom					
1969-1970 LSI	262	282	224	245	1.17
1972-1973 LSII	230	250	201	217	1.14
1975 SOFT	218	223	205	206	1.06

Note: The one-year rates for the LS assume one year of exposure for all currently married women at the time of interview, whereas all other rates are based on the actual number of married women years of experience. Standardization for age was based on the age distribution of currently married women from the 1970 census.

TABLE 12 Comparison of Previously Published Retrospective Estimates of Total Fertility Rates from the Survey of Fertility in Thailand (SOFT) with Revised and Adjusted Estimates (adjusted for differences in the proportion ever married in the SOFT and the 1970 census): Thailand

Period	Previously Published[a]	Revised[b]	Revised and Adjusted[b]
1965-1969	6.25	6.20	6.46
1970-1974	4.85	4.86	5.09

[a]Institute of Population Studies and National Statistical Office (1977), p. 56.
[b]Revised by Sauvaluck Piampiti and John Knodel, July 1978.

the SOFT were therefore adjusted by applying the 1970 census proportions of ever-married women, by age, to the SOFT marital fertility rates. The results of this adjustment combined with the revision discussed above are shown in the last column of Table 12; together they raise slightly the total fertility rates obtained from the birth histories. In both the previously published and the newly revised results, a substantial decline in total fertility is evident from the 1965–1969 period to the 1970–1974 period.

Estimates of the total fertility rate for each calendar year based on the retrospective analysis of the birth histories collected in SOFT are shown in Table 13; two-year moving averages, taken to smooth out irregularities, are also shown. Both sets of results are shown unadjusted and adjusted for the differences in the proportion of women ever married observed between the results of the 1970 census and the SOFT. Total fertility declines fairly slowly from 1960 to about 1967, when a more rapid decline begins: from 1967 to 1974, the estimated total fertility fell by about one third. As with all retrospective fertility estimates based on birth histories, caution is required in interpreting the results since they are sensitive to the failure of respondents to mention all births and to possible misplacement in time of the dates of particular births.

SUPPLEMENTAL EVIDENCE OF FERTILITY DECLINE

Birth-Order Statistics

Data on the distribution of registered births by birth order help to confirm the existence of a recent decline in fertility (Pardthaisong et al. 1978). It has commonly been observed that during the transition from high to low levels of fertility, the proportion of higher-order births declines while the

TABLE 13 Retrospective Estimates of Total Fertility Rates from the Survey of Fertility in Thailand (SOFT), Unadjusted and Adjusted for Differences in the Proportion of Ever-Married Women in the SOFT and in the 1970 Census: Thailand

	Single-Year Estimates		Two-Year Moving Averages[a]	
	Unadjusted	Adjusted	Unadjusted	Adjusted
1960	7.32	7.58	–	–
1961	6.89	7.17	7.10	7.37
1962	7.32	7.61	7.10	7.39
1963	6.35	6.61	6.83	7.11
1964	7.06	7.34	6.71	6.97
1965	6.35	6.60	6.71	6.97
1966	6.71	7.00	6.53	6.80
1967	6.30	6.56	6.50	6.78
1968	6.24	6.50	6.27	6.53
1969	5.76	6.01	6.00	6.25
1970	5.46	5.70	5.60	5.85
1971	5.38	5.62	5.42	5.66
1972	4.80	5.04	5.09	5.33
1973	4.12	4.32	4.46	4.68
1974	4.64	4.85	4.38	4.58

Note: Previously unpublished rates were revised by Sauvaluck Piampiti and John Knodel, July 1978.

[a]The two-year moving averages refer to the average of the year shown and the previous year.

proportion of lower-order births increases. This is of course a result of a shift from larger to smaller family sizes. Although birth registration is incomplete, changes in the distribution of registered births by birth order may be expected to reflect real changes in the actual distribution of all births unless changes in completeness are parity specific.

Table 14 summarizes the birth-order composition of registered births for Thailand from 1961 to 1975. The birth-order distribution was relatively stable during the early years of the 1960s, but from mid-decade onward it changed systematically, the change continuing into the 1970s. The proportion of all births that were either first order or first and second order increased annually almost without exception from 1965 on, whereas the proportion of births that were fourth and higher order declined. These findings are quite consistent with the observed trends in fertility over the same period. Caution in interpreting the sharp changes during the 1970s is in order since the proportion of births of unknown order increased sharply during this period.

TABLE 14 Distribution of Registered Births by Birth Order: Thailand

	Percent of All Births of Known Order[a]			
	First Births	First and Second Births	Fourth or Higher Births	Percent of All Births of Unknown Order[b]
1961	21.8	40.3	44.0	5.0
1962	21.4	39.6	44.7	5.4
1963	21.8	39.8	44.8	6.1
1964	21.1	38.9	45.8	6.9
1965	21.2	38.8	45.9	7.5
1966	21.8	39.6	45.4	7.8
1967	22.0	39.9	45.3	7.7
1968	22.7	40.6	44.6	8.0
1969	23.0	41.4	43.7	7.9
1970	23.0	41.6	43.4	7.9
1971	23.8	42.4	42.5	8.4
1972	25.7	45.2	40.0	9.3
1973	27.1	46.7	38.5	15.6
1974	28.8	48.7	36.6	16.1
1975	31.0	52.4	32.9	20.4
1961-1965[c]	21.5	39.5	45.0	6.2
1966-1970[c]	22.5	40.6	44.5	7.9
1971-1975[c]	27.3	47.1	38.1	14.0

[a]Excluding births of unknown order from denominator.
[b]Including births of unknown order in denominator.
[c]Unweighted five-year averages.

SOURCES: Calculations by Pardthaisong (1978) and additional calculations from data provided by the Ministry of Public Health.

Contraceptive Use Data

Additional supplemental evidence comes from survey data on the extent of contraceptive practice among married women of reproductive age and data on family planning acceptor statistics collected by the National Family Planning Program. The survey data show that contraceptive use increased dramatically between 1969 and 1975, coincident with the period of rapid fertility decline (Table 15). The increase is particularly marked in rural areas where the National Family Planning Program concentrated its efforts. The low level of use found for rural women in 1969 and the substantially higher use found for urban women in 1970 are consistent with the evidence indicating lower urban fertility and a more substantial urban fertility decline during the preceding decade. There is no direct

TABLE 15 Percent Who Are Currently Using and Percent Who Have Ever Used Contraception Among Currently Married Women Aged 15-44 as Reported in National Sample Surveys: Thailand

	Current Use	Ever Use
Rural		
1969 LS 1	10.9	14.4
1972 LS 2	22.8	29.4
1975 SOFT	34.8	49.0
Urban		
1970 LS 1	32.6	39.7
1973 LS 2	45.1	56.5
1975 SOFT	49.4	65.7
Kingdom		
1969-1970 LS 1	14.8	18.9
1972-1973 LS 2	26.3	33.6
1975 SOFT	36.7	51.2

SOURCE: Debavalya and Knodel (1978).

study for Thailand to indicate whether contraceptive use is likely to be overreported or underreported in surveys. There are no obvious grounds to suspect large biases in either direction, and even if such biases existed their effect should be minimal on the trends of contraceptive use derived from successive surveys, all of which followed a broadly similar methodology.

Data on new acceptors from the National Family Planning Program acceptor statistics are also consistent with a substantial fertility decline since the end of the 1960s. The number of new acceptors has continued to increase for most years during the 1970s, as shown in Table 16. It should be noted that there is some double counting and possible overregistration of new acceptors. The largest share of acceptors is attributed to the pill, which accounts for more than half of all acceptors for each year shown. An analysis of family planning acceptor statistics based on both private and public sources indicates that the expected trend in total fertility rates derived from estimating births averted is roughly consistent with the observed trend in those rates (Thailand Ministry of Public Health 1978a).

Data on Marital Status

In a country where most fertility is legitimate, changes in marital status can have a considerable impact on overall fertility without any change occurring in marital fertility, and in trying to account for changes in the overall level of fertility, marital status is an important factor to take into

TABLE 16 New Acceptors in the National Family Planning Program: Thailand

Year	Total[a]	Pill	IUD	Injectable Hormonal	Female Sterilizations	Vasectomy
1965-1971	946,738	505,314	336,392	–[a]	← 105,032 →	
1972	450,378	327,582	90,128	–[a]	← 32,668 →	
1973	411,729	268,674	93,449	–[a]	← 49,606 →	
1974	475,465	305,244	89,739	–[a]	73,702	6,780
1975	535,023	345,117	75,163	24,559	82,650	7,534
1976	627,239	376,707	71,894	73,357	95,131	10,150
1977	758,212	488,765	74,794	68,714	106,816	19,123
1978[b]	199,614	119,050	19,808	21,042	29,515	10,199

[a]Does not include other methods not listed, such as condoms. Also, totals for injectable acceptors prior to 1975 were combined with acceptors of other methods such as condoms and foam.
[b]First three months of 1978.

SOURCE: Thailand Ministry of Public Health (1978a).

TABLE 17 Proportions of Females Single by Age Group from Selected Sources: Thailand

	1960 Census				
Age Group	Reported Ages	Half-Year Adjusted Ages	1970 Census	1975 SOFT	1975 SPC
15-19	.862	.830	.810	.846	.786
20-24	.387	.352	.379	.415	.359
25-29	.141	.126	.156	.192	.156
30-34	.067	.062	.081	.101	.081
35-39	.042	.040	.053	.064	.048
40-44	.031	.030	.039	.039	.032
45-49	.026	.026	.030	.033	.015
Singulate mean age at marriage	22.10	21.64	21.97	22.46	21.96

account. The censuses of 1960 and 1970, the 1975 fifth round of the second SPC, and the SOFT all collected data on marriage, the last in considerable detail. The proportions of single females by age group from these sources are shown in Table 17. Two sets of proportions are given for 1960, one based on reported age and one obtained by regarding reported age as half a year older than true age to reflect the problem of age reporting discussed above.

The proportions marrying and the singulate mean age at marriage are broadly similar for the 1960 census (after adjustment), the 1970 census, and the 1975 SPC. The SOFT sample, however, shows substantially lower proportions ever married than the other sources and later marriage on

TABLE 18 Fertility and Mortality Indicators by Region and Period: Thailand

Parameter Estimated	Source	Time Period	Regional Estimates				Index Values, Kingdom = 1.00			
			Kingdom	North	Northeast	Central	South	North	Northeast	Central	South
Total fertility rate	*P/F*, registered births	1960	6.54	6.23	6.98	5.64	5.71	.95	1.07	.86	.87
	Own children	1960-1964	6.48	6.36	6.97	6.06	6.52	.98	1.08	.94	1.01
	Cohort parity	1960-1970	6.17	6.03	7.15	5.34	6.13	.98	1.16	.87	.99
	Adjusted registered births	1960-1969	6.44	5.92	7.25	5.44	6.09	.92	1.13	.84	.95
	SPC	1964-1965	6.30[a]	6.47	6.61	5.90[a]	6.02	1.03	1.05	.94	.96
	Own children	1965-1969	6.19	5.71	7.20	5.32	6.48	.92	1.16	.86	1.05
	Cohort parity	1970-1975	5.04	4.34	6.52	3.48	6.64	.86	1.29	.69	1.32
	Adjusted registered births	1970-1974	5.13	4.39	6.32	3.63	6.17	.86	1.23	.71	1.20
	SPC	1974-1976	4.90	3.74	6.25	3.93[b]	6.12	.76	1.28	.80[b]	1.25
Birth order-proportion not first births	Registration[c]	1960	.782	.782	.785	.786	.761	1.00	1.00	1.01	.97
		1965	.788	.791	.790	.783	.789	1.00	1.00	.99	1.00
		1970	.770	.754	.795	.747	.782	.98	1.03	.97	1.02
		1974	.712	.698	.766	.640	.744	.98	1.08	.90	1.04
Marital fertility[d]	SOFT	1973-1974	210	152	267	182	231	.72	1.27	.87	1.10
Infant mortality	SPC	1964-1965	84.3[a]	96.5	83.4	94.0[a]	48.5	1.14	.99	1.12	.58
	Indirect[e]										
	1970 census	1966	70.1	81.4	78.9	55.4	54.7	1.16	1.13	.79	.78
	1974 SPC	1970	61.1	77.4	68.8	35.4	60.0	1.27	1.13	.58	.98
	1975 SPC	1971	61.5	79.7	70.6	38.5	53.6	1.30	1.15	.63	.87
	SPC	1974-1976	51.9	74.0	52.3	40.0[b]	52.4	1.43	1.01	.77[b]	1.01

[a] Excludes Bangkok-Thonburi.

[b] Weighted average of central (excluding Bangkok-Thonburi) and Bangkok-Thonburi.

[c] Data from Thailand Ministry of Public Health.

[d] Age standardized 20-24.

[e] Infant mortality rates obtained from Coale and Demeny (1966) "North" family life tables corresponding to indirect estimates of $_2q_0$, $_3q_0$, and $_5q_0$.

average. Given the consistency of the other data sets, we conclude that the SOFT marriage data are not representative. Considering the other distributions only, there seems to have been no significant change in marriage patterns between 1960 and 1975, and fertility changes cannot be explained in this way.

REGIONAL VARIATION

Regional variation is an important factor in understanding levels and trends of fertility and, to a lesser extent, mortality in Thailand. Some of the methods of analysis presented above are more suitable than others for application to regions. Own-children analysis has been applied at the regional level; the completeness of birth registration can be estimated at the regional level by comparison with reported average parity in 1960 and by comparing cumulated cohort fertility with parity in 1970 and 1975; cohort parity increment methods can also be applied for the periods 1960–1970 and 1970–1975; and the Surveys of Population Change provide regional estimates of fertility.

The estimates are summarized in Table 18, by source and time period, in terms of the total fertility rate. The regional estimates are also shown as index values, taking the national estimate as 100; these index values thus provide an indication of regional variation independent of level. Table 18 also shows age-standardized marital fertility rates by region from the SOFT; regional estimates of the infant mortality rate from the Surveys of Population Change and from 1970 census information on children ever born and surviving, the 1974 first round of the second SPC, and the 1975 SOFT; and proportions of births other than first births among all registered births of known order by region for selected years from 1960 to 1974.

The fertility estimates show impressive consistency even at the regional level. The index numbers show the North having fertility slightly below the national average prior to 1970, after which it falls rapidly; the Northeast starts somewhat above average in the early 1960s and becomes increasingly above average thereafter; the Central region starts below average and declines further; the South starts close to average in the early 1960s and becomes above average by the early 1970s. The marital fertility rates from the SOFT for 1973–1974 show a similar pattern, although they indicate substantially lower fertility in the North than in the Central region. The birth-order composition of registered births provides additional confirmation of the changes that have taken place, showing nearly perfect homogeneity for 1960 and 1965 followed by declines in higher-order births, fastest in the Central and North regions and slowest in the Northeast and South regions.

TABLE 19 Age Patterns of Fertility by Period and Source of Estimate: Thailand

Source	Period	Standardized Rates by Age Groups							Observed TFR
		15-19	20-24	25-29	30-34	35-39	40-44	45-49	
Birth registration[a]	1960	.0129	.0435	.0510	.0446	.0353	.0100	.0029	4.704
SOFT[b]	1960-1964	.0161	.0456	.0456	.0370	.0340	.0165	.0051	7.170
Own children[c]	1960-1964	.0133	.0423	.0483	.0434	.0332	.0164	.0031	6.480
SPC[d]	1964-1965	.0109	.0423	.0495	.0387	.0363	.0184	.0039	6.119
SOFT[b]	1965-1969	.0138	.0406	.0469	.0406	.0319	.0212	.0051	6.460
Own children[c]	1965-1969	.0144	.0431	.0483	.0420	.0333	.0162	.0031	6.190
CPI[e]	1960-1970	.0130	.0410	.0488	.0441	.0337	.0164	.0031	6.170
Birth registration[a]	1970	.0148	.0452	.0477	.0405	.0317	.0157	.0046	4.374
SOFT[b]	1970-1974	.0114	.0378	.0451	.0409	.0385	.0212	.0052	5.085
CPI[e]	1970-1975	.0151	.0423	.0466	.0401	.0296	.0216	.0050	5.040
SPC[d]	1974-1976	.0165	.0487	.0504	.0372	.0292	.0144	.0037	4.899
Birth registration[a]	1975	.0162	.0433	.0476	.0398	.0303	.0163	.0067	3.699

[a]Rates calculated from birth registration data adjusted for age but not level.
[b]From Survey of Fertility in Thailand, revised and adjusted.
[c]From own-children analysis of 1970 census.
[d]From Survey of Population Change.
[e]From intersurvey cohort parity increment.

The infant mortality estimates are not quite so consistent, and it must be borne in mind that the indirect estimates come from estimates of survivorship to ages 2, 3, and 5, converted into infant mortality rates through the "North" family of regional model life tables. In general, however, it appears that the North region has the highest infant mortality, followed by the Northeast, the South, and, finally, the Central region. Over time, the North's disadvantage seems to have been getting worse, and the South's advantage seems to have been eroded, but the trends are neither entirely clear nor consistent.

AGE PATTERNS OF FERTILITY

Many of the methods presented in this report have estimated both the aggregate level and the age pattern of fertility. The different levels of these estimates makes it difficult to observe the variations in age pattern of fertility. Table 19 presents all the fertility schedules, estimated on a normalized basis with a total fertility rate of 1.0, and orders them by approximate time period. The distributions are reasonably consistent, but they show no clear trend in the age pattern of fertility over time. This is somewhat surprising, since fertility declines often start, or are concentrated, among older women; in the case of Thailand, fertility seems to have declined at all ages. However, a comparison of marital fertility rates from the Longitudinal Surveys and the Survey of Fertility in Thailand does show a more rapid decline of marital fertility for older women than for younger women (Debavalya and Knodel 1978). Contraceptive use data from the SOFT, on the other hand, show fairly high levels of use among younger women, consistent with the apparently rather minor changes over time in the age pattern of fertility.

COMPARISON OF FERTILITY AND MORTALITY ESTIMATES FROM DIFFERENT SOURCES

It is convenient for purposes of comparison to summarize the various national estimates of fertility and mortality presented above, which were obtained by a range of methodologies and which refer to different time periods, in terms of simple aggregate indicators.

For fertility, the indicator chosen is the total fertility rate; where necessary, crude birth rates and marital fertility rates have been converted into corresponding levels of total fertility, using observed age patterns of fertility and observed proportions of women married, respectively. Table 20 shows the total fertility rates by time and source; Figure 1 (above) shows estimates of total fertility for calendar years, smoothed by taking

TABLE 20 Estimates of Total Fertility by Period and Method: Thailand

Method/Source	1955	1957	1959	1961		1963		1965		1967		1969		1971		1973		1975	1977
SOFT[a,b]				7.4	7.4	7.1	7.0	7.0	6.8	6.8	6.5	6.3	5.9	5.7	5.3	4.7	4.6		
Adjusted registered births[b]				6.2	6.2	6.4	6.7	6.9	6.6	6.2	6.0	5.8	5.5	5.4	5.3	5.1	4.8	4.6	
Reverse survival																			
1975[c]				6.3	6.5	6.5	6.5	6.5	6.4	6.1	6.1	5.8	5.5	5.3	5.0	4.2	3.9	4.1	
1970[c]			6.2	6.5	6.5	6.3	6.6	6.9	6.0	5.6	5.5	5.6							
SPC								6.3									4.9		
LS																			
births, 1 year before[c]												6.1			5.3				
births, 2 years before[c]										5.3				4.6					
Cohort parity increment								6.2								5.0			
Stable population analysis[c]		6.5							6.3										
Own children				6.5		6.5		6.5		6.0									
Reverse survival using reported age distribution[c]		5.7			6.5					6.0									
Reverse survival from SPC's (reported midyear populations)[c]		6.1			6.3					6.2						4.8			
Reverse survival using adjusted distribution[c]		6.1							6.2										

[a] Revised and adjusted rates.
[b] Two-year moving average.
[c] TFR's obtained by conversion from other indicator.

two-year moving averages, from four sources—adjusted registered births, the SOFT, and two single-year age distributions obtained by reverse survival. The agreement between the estimates obtained, by independent methodologies, for comparable time periods is impressive.

The estimates shown in Figure 1 are particularly interesting. The downward bias of the estimates obtained from reverse survival for the four years before the survey shows up clearly for both the census and the SPC age distributions; in both cases the bias appears to be less marked for the point nearest the survey (based on an average of children aged 0 and 1) than for the second point (based on an average of children aged 1 and 2). The SOFT estimates show a rather similar pattern, the last three points showing an apparent acceleration of the fertility decline; it is tempting to assume that the same sort of dating error may be affecting both the age distributions and the fertility history. The overall level of the SOFT estimates, to 1970, is consistently and suspiciously higher than those obtained from the other three methods, possibly reflecting a tendency to bunch events into the period 5–15 years before the survey. The adjusted birth registration rates show a dubious pattern of rise and fall to 1966, but follow a fairly constant trend thereafter; the early rise and subsequent decline may be due to improving registration in the early 1960s, with an increase in delayed registration in the mid–1960s. All four sources show, however, that fertility has declined rapidly, the decline having started around 1965; the minimum decline in the total fertility rate by 1975 is 28 percent.

In the case of mortality, it is less easy to select one single indicator, since the methods applied are often estimating mortality for different periods of life. It is also more difficult to convert one measure of mortality into another, given the uncertainty surrounding the underlying age pattern of mortality. Therefore, four different indicators are shown in Table 10: child mortality estimates, from the SPC and from indirect methods, are shown in the form of probabilities of dying by age 5 and of the infant mortality rate; adult mortality estimates, from the SPC's and from adjusted registered deaths, are presented in the form of expectation of life at age 10, and in the case of the SPC, expectation of life at birth. It must be remembered that the infant mortality rates estimated by indirect methods were obtained by using an assumed age pattern of childhood mortality; a different pattern would give different estimates. It is clear, however, that child mortality has declined in the recent past.

The Surveys of Population Change show a decline of 21 percent in the probability of dying by exact age 5 between the mid-1960s and the mid-1970s, although this figure exaggerates the true change, since Bangkok was excluded from the earlier survey. The indirect child mortality estimates,

when considered internally, indicate a decline over approximately a five-year interval of one level in the Coale and Demeny (1966) life tables, equivalent to a decline in ${}_5q_0$ of close to 15 percent. When differences between the surveys are considered, a similar decline may be observed from the 1970 census to the 1974–1975 SPC results. The estimates derived from the SOFT, however, show virtually no decline after 1970, though for reasons noted earlier these estimates are not really comparable with the rest despite the fact that they may be more reliable.

The decline of adult mortality seems to have been less marked, with expectation of life at age 10 remaining constant for males from the first SPC to the second, although improving by about a year and a half for females.

Glossary

AGE HEAPING A tendency for enumerators or respondents to report certain ages instead of others; also called age preference or digit preference. Preference for ages ending in 0 or 5 is widespread.

AGE PATTERN OF FERTILITY The relative distribution of a set of *age-specific fertility rates*. It expresses the relative contribution of each age group to *total fertility*.

AGE-SPECIFIC FERTILITY RATE The number of births occurring during a specified period to women of a specified age or age group, divided by the number of person-years-lived during that period by women of that age or age group. When an age-specific fertility rate is calculated for a calendar year, the number of births to women of the specified age is usually divided by the midyear population of women of that age.

AGE STANDARDIZATION A procedure of adjustment of crude rates (birth, death, or other rates) designed to reduce the effect of differences in age structure when comparing rates for different populations.

BIRTH HISTORY A record of the number and dates of all live births experienced by a particular woman; see also *pregnancy history*. Survival of each child to the date of the interview and, where pertinent, the date of death are also generally recorded.

BIRTH ORDER The ordinal number of a given live birth in relation to all previous live births of the same woman (e.g., 5 is the birth order of the fifth live birth occurring to the same woman).

BIRTH RATE See *crude birth rate*.

CHILDBEARING AGES The span within which women are capable of bearing children, generally taken to be from age 15 to age 49 or, sometimes, to age 44.

CHILDREN EVER BORN(E) The number of children ever borne alive by a particular woman; synonymous with *parity*. In demographic usage, stillbirths are specifically excluded.

COHORT A group of individuals who experienced the same event in the same period. Thus an age cohort is a group of people born during a particular period, and a marriage cohort is a group of people who married during a particular period. The effects of a given set of mortality or fertility rates are often illustrated by applying them to hypothetical cohorts.

COHORT FERTILITY The fertility experienced over time by a group of women or men who form a birth or a marriage cohort. The analysis of cohort fertility is contrasted with that of *period fertility*.

CRUDE BIRTH RATE The number of births in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as births per thousand population. The crude birth rate for a single year is usually calculated as the number of births during the year divided by the midyear population.

CRUDE DEATH RATE The number of deaths in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as deaths per thousand population. The crude death rate for a single year is usually calculated as the number of deaths during the year divided by the midyear population.

CUMULATED FERTILITY An estimate of the average number of children ever borne by women of some age x, obtained by cumulating *age-specific fertility rates* up to age x; also often calculated for age groups.

DEATH RATE See *crude death rate*.

EXPECTATION OF LIFE AT BIRTH The average number of years that a member of a *cohort* of births would be expected to live if the cohort were subject to the mortality conditions expressed by a particular set of age-specific mortality rates.

FERTILITY HISTORY Either a *birth history* or a *pregnancy history*.

FORWARD SURVIVAL A procedure for estimating the age distribution at some later date by projecting forward an observed age distribution. The procedure uses *survival ratios*, often obtained from model *life tables*. The procedure is basically a form of population projection without the introduction of new entrants (births) to the population.

GENERAL FERTILITY RATE The ratio of the number of live births in a period to the number of person-years-lived by women of *childbearing ages* during the period. The general fertility rate for a year is usually calculated as the number of births divided by the number of women of childbearing ages at midyear.

GROSS REPRODUCTION RATE The average number of female children a woman would have if she survived to the end of her childbearing years and if, throughout, she were subject to a given set of *age-specific fertility rates* and a given *sex ratio at birth*. This number provides a measure of replacement fertility in the absence of mortality.

GROWTH RATE The increase or decrease of a population in a period divided by the number of person-years-lived by the population during the same period. The

increase in a population is the result of a surplus (or deficit) of births over deaths and a surplus (or deficit) of immigrants over emigrants. (The annual increase is often expressed as a fraction of the total population at the beginning of the year, but this convention has the inconvenient characteristic of not being readily defined for a five-year interval and of being unequal to the difference between the birth rate and the death rate even in the absence of migration.) See also *rate of natural increase.*

INFANT MORTALITY RATE The number of deaths of children under 1 year of age occurring in a year per 1,000 live births occurring in the same year; also used in a more rigorous sense to mean the number of deaths that would occur under 1 year of age in a *life table* with a *radix* of 1,000.

LIFE TABLE A listing of the number of survivors at different ages (up to the highest age attained) in a hypothetical cohort subject from birth to a particular set of age-specific mortality rates. The rates are usually those observed in a given population during a particular period of time. The tabulations accompanying a life table include other features of the cohort's experience: its expectation of life at different ages, the probability of surviving from the beginning of each age interval to the end of that interval, etc.

MARITAL FERTILITY Any measure of fertility in which the births (in the numerator) are births to married women and in which the number of person-years-lived (in the denominator) also pertains to married women. In some instances, the designation "married" includes persons in consensual unions.

MEDIAN The central value of a set that is ordered by size or some other characteristic expressed in numbers.

MEAN AGE OF CHILDBEARING The average age at which a mortality-free *cohort* of women bear their children according to a set of *age-specific fertility rates.*

MEAN AGE OF CHILDBEARING IN THE POPULATION The average age of the mothers of the children born in a population during a year. This measure incorporates the effects of both mortality and the age distribution.

MODEL LIFE TABLE An expression of typical mortality experience derived from a group of observed *life tables.*

MOVING AVERAGES The successive averaging of two or more adjacent values of a series in order to remove sharp fluctuations.

NATURAL FERTILITY The age pattern of *marital fertility* observed in non-contraceptive populations where reproductive behavior is not affected by the number of children already born.

NET MIGRATION The difference between gross immigration and gross emigration.

NET REPRODUCTION RATE The average number of female children born per woman in a *cohort* subject to a given set of *age-specific fertility rates,* a given set of age-specific mortality rates, and a given *sex ratio at birth.* This rate measures replacement fertility under given conditions of fertility and mortality: it is the ratio of daughters to mothers assuming continuation of the specified conditions of fertility and mortality.

OWN-CHILDREN METHOD A refinement of the *reverse survival* procedure for fertility estimation, whereby estimates of *age-specific fertility rates* for the recent

past are obtained by relating mothers to their own children, using information on relationship and other characteristics available from a census or survey.

PARITY See *children ever born*.

PERIOD FERTILITY The fertility experienced during a particular period of time by women from all relevant birth or marriage *cohorts*; see also *cohort fertility*.

PREGNANCY HISTORY A record of the number and the dates of occurrence of all the pregnancies experienced by a particular woman. The outcome of the pregnancy—live birth, stillbirth, fetal death—is also recorded.

${}_xq_0$ The probability of dying between birth and some exact age x, sometimes also written $q(x)$: q is the probability of dying, 0 is birth, and x is the exact age up to which the probability of dying refers.

RADIX The hypothetical birth cohort of a *life table*. Common values are 1, 1,000, and 100,000.

RATE OF NATURAL INCREASE The difference between the births and deaths occurring during a given period divided by the number of person-years-lived by the population during the same period. This rate, which specifically excludes changes resulting from migration, is the difference between the *crude birth rate* and the *crude death rate*.

RETROSPECTIVE SURVEY A survey that obtains information about demographic events that occurred up to some specific time, generally the time of the survey.

REVERSE SURVIVAL A technique to estimate an earlier population from an observed population, allowing for those members of the population who would have died according to observed or assumed mortality conditions. It is used as a method of estimating fertility by calculating from the observed number of survivors of a given age a the expected number of births that occurred a years earlier. (In situations for which mortality is known or can be reliably estimated, reverse survival can be used to estimate migration.)

ROBUSTNESS A characteristic of estimates that are not greatly affected by deviations from the assumptions on which the estimation procedure is based.

SEX RATIO AT BIRTH The number of male births for each female birth, or male births per 100 female births.

SINGULATE MEAN AGE AT MARRIAGE (SMAM) A measure of the mean age at first marriage, derived from a set of proportions of people single at different ages or in different age groups, usually calculated separately for males and females.

SURVIVAL RATIO The probability of dying between one age and another; often computed for age groups, in which case the ratios correspond to those of the person-years-lived function, ${}_nL_x$, of a *life table*.

SYNTHETIC PARITY The average parity calculated for a hypothetical cohort exposed indefinitely to a set of period *age-specific fertility rates*.

TOTAL FERTILITY RATE (TFR) The average number of children that would be born per woman if all women lived to the end of their childbearing years and bore children according to a given set of *age-specific fertility rates*; also referred to as total fertility. It is frequently used to compute the consequence of childbearing at the rates currently observed.

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COMMITTEE ON
POPULATION AND DEMOGRAPHY Report No. 3

Fertility and Mortality Changes in Honduras, 1950–1974

Kenneth Hill

Committee on Population and Demography
Assembly of Behavioral and Social Sciences
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1980

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NOTE: Members of the Committee and its panels and working groups participated in this project in their individual capacities; the listing of their organizational affiliation is for identification purposes only, and the views and designations used in this report are not necessarily those of the organizations mentioned.

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Preface

The Committee on Population and Demography was established in April 1977 by the National Research Council, in response to a request by the Agency for International Development (AID) of the U.S. Department of State. It was widely felt by those concerned that the time was ripe for a detailed review of levels and recent trends of fertility and mortality in the developing world. Although most people in the demographic community agree that mortality has declined in almost all developing countries during the last 30 years, there is uncertainty about more recent changes in mortality in some countries, about current levels of fertility, and about the existence and extent of recent changes in fertility.

In 1963, a Panel on Population Problems of the Committee on Science and Public Policy of the National Academy of Sciences published a report entitled *The Growth of World Population*. The appointment of that panel and the publication of its report were expressions of the concern then felt by scientists, as well as by other informed persons in many countries, about the implications of population trends. At that time, the most consequential trend was the pronounced and long-continued acceleration in the rate of increase of the population of the world, and especially of the population of the poorer countries. It was estimated in 1963 that the annual rate of increase of the global population had reached 2 percent, a rate that, if continued, would cause the total to double every 35 years. The disproportionate contribution of low-income areas to that acceleration was caused by rapid declines in mortality combined with high fertility that

remained almost unchanged: the birth rate was nearly fixed or declined more modestly than the death rate.

Since the earlier report, however, the peak rate of growth in the world's population has apparently been passed. A dramatic decline in the birth rate in almost all the more developed countries has lowered their aggregate annual rate of increase to well below 1 percent, and the peak rate of increase has also apparently been passed in the less-developed parts of the world as a whole. A sharp decline in fertility in many low-income areas has more than offset the generally continued reduction in the death rate, although the rate of population increase remains high in almost all less-developed countries.

The causes of the reductions in fertility—whether they are the effect primarily of such general changes as lowered infant mortality, increasing education, urban rather than rural residence, and improving status of women or of such particular changes as spreading knowledge of and access to efficient methods of contraception or abortion—are strongly debated. There are also divergent views of the appropriate national and international policies on population in the face of these changing trends. The differences in opinion extend to different beliefs and assertions about what the population trends really are in many of the less-developed countries. Because births and deaths are recorded very incompletely in much of Africa, Asia, and Latin America, levels and trends of fertility and mortality must be estimated, and disagreement has arisen in some instances about the most reliable estimates of those levels and trends.

It was to examine these questions that the Committee on Population and Demography was established within the Assembly of Behavioral and Social Sciences of the National Research Council. It was funded for a period of three years by AID under Contract No. AID/pha-C-1161. The Committee has undertaken three major tasks:

1. To evaluate available evidence and prepare estimates of levels and trends of fertility and mortality in selected developing nations;
2. To improve the technologies for estimating fertility and mortality when only incomplete or inadequate data exist (including techniques of data collection);
3. To evaluate the factors determining the changes in birth rates in less-developed nations.

Given the magnitude of these tasks, the Committee decided to concentrate its initial efforts on the first two tasks; it initiated work on the third task in 1979.

The Committee approaches the first task through careful assessment, by

internal and external comparison, and through analysis, by application of the most reliable methods known, of all the data sources available. Each of the country studies therefore consists of the application of a range of methods to a number of data sets. Best estimates of levels and recent trends are then developed on the grounds of their consistency and plausibility and the robustness of the individual methods from which they were derived.

The Committee's second task, refinement of methodology, is seen as a by-product of achieving the first. The application of particular methods to many different data sets from different countries and referring to different time periods will inevitably provide valuable information about the practical functioning of the methods themselves. Particular data sets might also require the development of new methodology or the refinement of existing techniques.

The Committee set three criteria for identifying countries to study in detail: that the country have a population large enough to be important in a world view; that there be some uncertainty about levels and recent trends of fertility or mortality; and that sufficient demographic data be available to warrant a detailed study. After a country has been selected for detailed study, the usual procedure is to set up a panel or working group of experts, both nationals of the country and others knowledgeable about the demography and demographic statistics of the country. The role of these panels and working groups, which generally include at least one Committee member, is to carry out the comparisons and analyses required. A small staff assists the Committee, panels, and working groups in their work.

As of early 1980, 120 population specialists around the world were members of one or more panels or working groups. This number includes 77 specialists from developing nations. The Committee, the Assembly, and the National Research Council are grateful for the unpaid time and effort these experts have been willing to give.

Each country being studied has a different mix of data sources and different problems with data errors. Therefore, there is no standard pattern for all the reports. However, each report includes a summary of the main findings regarding estimates of fertility and mortality, a description of the data sources available, and a presentation of the analyses that were carried out, classified by type of data analyzed; detailed methodological descriptions are included where necessary in appendixes.

In some of the reports the estimates of fertility and mortality are presented as ranges. The use of a range is deliberate. It indicates that the panel and the Committee are confident that the range includes the true value, but have concluded that the evidence does not warrant selecting a

single figure as best. The range conveys an important aspect (uncertainty) of the estimation. Ideally, in constructing an average for several populations in each of which estimation is presented as a range, an aggregate range should be calculated (as the population-weighted average of the constituents). The user who selects a single figure from the middle of the range does so at the risk of misleading simplification.

This report, on levels and recent trends of fertility and mortality in Honduras, is No. 3 in a series produced by the Committee. The Committee's thanks for this study are due to Kenneth Hill, who was largely responsible for its preparation, in collaboration with Committee members and with other members of the Committee staff. All the permanent staff of the Committee have helped in some way with the production of this report, but special thanks are due to Brenda Buchbinder, administrative assistant, to Mary Anne Fitzgerald, for carrying out many tedious and repetitive calculations, and to Solveig Padilla, for coping with the tables.

Thanks are also due to the staff of the National Research Council, in particular to David A. Goslin, executive director of the Assembly of Behavioral and Social Sciences, and Eugenia Grohman, associate director for reports of the Assembly, for their support, assistance, and advice. We are also grateful to reviewers of early drafts of this report, in particular to Shea Rutstein of the World Fertility Survey. Hitherto unpublished data from a sample of the 1974 census, which were obtained from the Centro Latinoamericano de Demografia, Santiago, Chile, have proved to be of great value in the analysis.

ANSLEY J. COALE, *Chairman*
Committee on Population and Demography

Summary and Conclusions

Estimates of fertility for the period from 1950 to the early 1970s are available from registered births and from the age structure of the population. Total fertility rates have been calculated for each year from 1951 to 1974 after inflating registered births by a factor of 1.18 to allow for underregistration and after inflating the 1974 census population by a factor of 1.11 at all ages to allow for estimated underenumeration relative to 1961; these rates are shown in Figure 1. Figure 1 also shows total fertility rates for 1971–1972 obtained from a multiround survey and from a retrospective survey. The pattern shown, of total fertility rising from a level of 6.74 in 1951 to a peak around 7.75 in the early 1960s and declining somewhat toward the middle 1970s, may be somewhat distorted by bunching of delayed birth registrations and by changes in the completeness of registration. It is clear, however, that fertility is very high and has been since the early 1950s; there is no firm evidence of any trend in fertility, although there is some indication that fertility in 1973 and 1974 may have been 3 or 4 percent lower than in 1972. The total fertility rate for the period 1950–1974 was probably between 7.0 and 7.5.

In combination with estimates of child mortality or of the rate of population growth, the age and sex composition of a population can be used to estimate the birth rate. The observed rates of population growth for the population of Honduras are seriously distorted by changes in the completeness of enumeration, which probably increased from 1945 to 1950, and again from 1950 to 1961, but then declined in 1974. Child mortality estimates were therefore used to obtain estimates of the birth

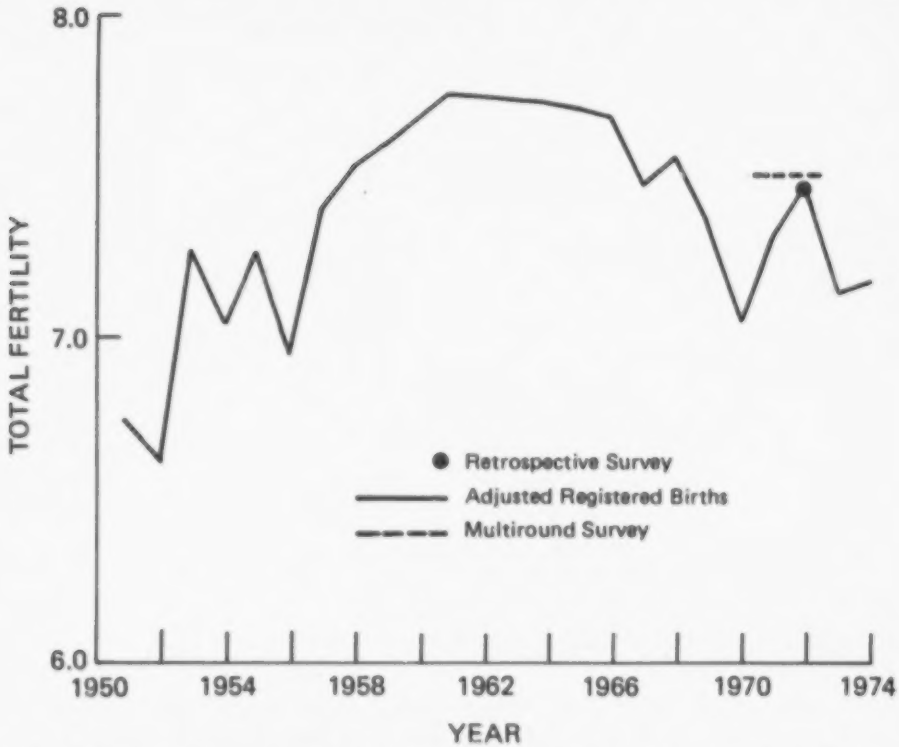

FIGURE 1 Total fertility rates from adjusted registration data, by year, 1951–1974, with comparable estimates: Honduras.

NOTE: The estimate for each year refers to the middle of the calendar year.

rate from the 1974 age structure of the population, and an extrapolation of child mortality trends was used for an analysis of the 1961 age distribution. Further extrapolation to 1950 was not considered justified, but an attempt was made to analyze the 1950 age structure by using the observed rate of population growth between 1945 and 1950. The resultant estimates of fertility and mortality were so low, however, in relation to those obtained for 1961 and 1974 that the calculations were repeated with a much lower rate of population growth, and more consistent results were obtained. The estimates of the birth rate obtained by analyzing the age structure are shown in Table 1; for comparative purposes, estimates for census years from adjusted registered births are also shown. The general picture is one of consistently high fertility, with birth rates around 50 per 1000 throughout the period. With the exception of 1950, the birth rates based on the age structure are consistent with those obtained from adjusted registered births.

TABLE 1 Estimates of the Birth Rate from Population Age Structure and Other Sources: Honduras

	1950	1951-1955	1956-1960	1961	1964-1968	1969-1973	1974
Age structure	46.4[a]	55.8[b]	49.6[b]	53.7[a]	50.7[c]	45.5[c]	50.7[a]
Adjusted registered births	50.9[d]			54.1			49.9
Multiround survey						49.2[e]	

[a] Stable population analysis, census age distribution (r = 1.5 percent in 1950).
[b] Reverse survival of 1961 census age distribution.
[c] Reverse survival of 1974 census age distribution.
[d] 1951.
[e] 1971-1972.

Useful information on mortality is somewhat more scanty than that on fertility, since registration of deaths was undoubtedly improving in the 1950s. The stable population analysis of the 1950 age distribution using a rate of growth of 1.5 percent per year gives a crude death rate in excess of 30 per 1000, suggesting a level of mortality around level 7 in the "North" family of the Coale-Demeny (1966) model life table system. Doubts about the accuracy of the 1950 age distribution make all mortality estimates for 1950 very uncertain, though what evidence there is suggests that mortality may have fallen very rapidly between 1950 and 1961, by which time the crude death rate is estimated to have been about 19 per 1000, mortality level 12 in the "North" family. Mortality continued to decline from 1961 to 1974, albeit somewhat more gradually: the crude death rate in 1974 was about 14 per 1000, mortality level 14.5 in the "North" family. Estimates of the overall level of mortality are rather consistent for the early 1970s, although some doubts remain about the age pattern of mortality. Estimates for the 1960s are somewhat less soundly based, but fit together well. Mortality estimates for 1950 are really little more than guesses, since the observed rate of population growth is not consistent with the age structure and the level of fertility. Table 2 shows various mortality indicators by period and source.

Information on international migration is incomplete because data on place of birth are not available either from the 1974 census of Honduras or from censuses of certain neighboring countries. From what information there is, however, it seems unlikely that international migration has

TABLE 2 Estimates of Mortality Measures for the Period from 1950 to 1974: Honduras

Mortality Measure	1950[a]	1961[a]	c. 1969[b]	1971-1972[c]	1974[a]
Crude death rate	30.7	19.2	14.3	14.2	14.5
Infant mortality rate	(204)	(127)	118	117	(98)
e_0 Male	(32.0)	(44.3)	50.7	50.9	(50.3)
e_{10} Male	(42.3)	(49.1)	53.5	55.4	(52.1)
e_0 Female	(35.0)	(47.5)	54.4	55.5	(53.8)
e_{10} Female	(44.6)	(52.7)	56.3	56.7	(54.8)
${}_5q_0$ Male	(.356)	(.226)	.183	.208	(.170)
${}_5q_0$ Female	(.324)	(.204)	.162	.152	(.151)

Note: Figures in parentheses are derived from model life tables, "North" family.

[a] Obtained by stable population analysis of census age distribution (see Table 6).
[b] Obtained by application of indirect mortality estimation procedures to data from 1972 Retrospective Survey (see Table 19).
[c] Obtained from 1970-1972 Multiround Demographic Survey (see Table 21).

affected population growth significantly, in either direction, in the period under consideration. It is possible that some net immigration, largely from El Salvador, has taken place, but without birthplace data from the 1974 census there is no firm evidence.

Assuming that net migration has been negligible, population growth will have been equal to the rate of natural increase. It seems likely that the rate of growth in 1950 was about 1.5 percent per year and had increased by 1961 to about 3.3 percent, partly as a result of a small rise in fertility but more importantly as a result of a very sharp drop in mortality. The rate of growth continued to increase after 1961, though much more slowly, as mortality declined more slowly; in the early 1970s, it is estimated to have been about 3.6 percent per year. Registration figures for 1973 and 1974 suggest a modest decline in fertility, though there is some reason to suppose that birth registration may have decreased slightly in those years.

Fertility and Mortality Changes in Honduras, 1950–1974

INTRODUCTION

Honduras has a relatively small population, enumerated as 2.66 million in the 1974 census, and therefore does not meet the first criterion of the Committee for a detailed country study. However, there is clear evidence that mortality has declined in the recent past, and there is a variety of types of demographic data available covering a fairly long time period. Thus for reasons of methodology alone, the recent demographic history of Honduras seemed worth looking into, and it was decided that the Committee staff should undertake a national-level study.

DATA SOURCES

Honduras has a relatively long history of censuses, stretching back to early in this century, and a relatively long-established vital registration system, although registration of both births and deaths is classified by the U.N. Statistical Office as being less than 90 percent complete. The only information available from the censuses before 1950 is total population size; from 1951 onward, the vital registration system provides births by five-year age group of mother and deaths by age group and sex. The data sources available are therefore limited to the population censuses of 1950, 1961, and 1974, registered births and deaths for the years 1951–1974, a four-round national sample survey carried out between the end of 1970 and late 1972, and a retrospective survey included in the last round of the

TABLE 3 Data Sources by Evidence Available: Honduras

Type of Evidence	Censuses			Vital Registration	Multiround Survey	Retrospective Survey
	1950	1961	1974	1951-1974	1970-1972	1972
Age/sex distribution						
Five-year age groups	X	X	X		X	X
Single years			X			
Own children						
Births by five-year age group of mother				X	X	X
Deaths by five-year age group and sex				X	X	
Children ever born by age of mother			X[a]			X
Children surviving by age of mother			X[a]			X
Survival of mother (orphanhood)			X[a]			X
Survival of first husband (widowhood)						X
Marital status by five-year age group and sex		X			X	X

[a] From 10-percent sample of census households.

multiround survey. Table 3 summarizes the data relevant to this study by source.

RESULTS CLASSIFIED BY TYPE OF EVIDENCE

POPULATION AGE DISTRIBUTIONS

Age and sex distributions of the population of Honduras are available from the censuses of 1950, 1961, and 1974; distributions obtained on a sample basis are also available for 1970–1972, based on person-years lived, and for 1972. The total population size is also available from the censuses of 1935, 1940, and 1945. Table 4 shows the total population (by sex, from 1950) for each census year, with the implied intercensal growth rates. The trend of these growth rates shows a rise from 1940 to 1961 and then a decline from 1961 to 1974. Table 5 gives a rough indication of each age structure, giving for each sex the proportions in the broad age groups 0–14, 15–44, and 45 and over, for 1950, 1961, 1970–1972, 1972, and 1974. From 1961 onward, the age distributions are rather similar, the two census-based distributions showing marginally older populations than the two sample-based distributions. The 1950 census age distribution is, however, quite different from the others, showing a substantially older population.

Age distributions can be used to estimate underlying parameters of fertility and mortality (1) by applying stable population analysis, using either an estimate of the population growth rate or an independent estimate of child mortality, and (2) by applying reverse survival to young children, also using an estimate of child mortality, to estimate births in a period before the census or survey. In both cases, the estimates depend only on the age structure of the population and not on its absolute size. The questions of completeness of enumeration of the various censuses, and thus of absolute population size, can therefore be left to the end of this section, which first presents estimates of fertility and mortality obtained from stable population analysis and fertility estimates obtained by reverse survival.

Stable Population Analysis, 1950, 1961, and 1974

A comparison of the proportions in each age group of the female age distributions from each census with suitable stable population distributions indicates that the age distributions were not seriously distorted. The procedure recommended by the United Nations Manual IV (1967) in such situations, to apply stable population analysis to the male age distribution, was followed. No estimate of child mortality was available for 1950, so the

TABLE 4 Total Population (thousands) for Census Years and Implied Rates of Growth, 1935-1974: Honduras

	Census Year										
Sex	1935	*r* (%)	1940	*r* (%)	1945	*r* (%)	1950	*r* (%)	1961	*r* (%)	1974
Male	n.a.	—	n.a.	—	n.a.	—	686	2.9	939	2.6	1317
Female	n.a.	—	n.a.	—	n.a.	—	683	3.0	946	2.7	1340
Total	962	2.8	1108	1.6	1201	2.6	1369	3.0	1885	2.7	2657

Note: n.a. is not available.

TABLE 5 Proportion of the Population in Broad Age Groups by Sex, 1950, 1961, 1970-1972, 1972, and 1974: Honduras

Age/Sex Group	1950	1961	1970-1972	1972	1974
Males					
0-14	0.415	0.489	0.500	0.504	0.492
15-44	0.427	0.390	0.377	0.376	0.386
45+	0.159	0.121	0.124	0.120	0.122
Females					
0-14	0.397	0.468	0.480	0.474	0.469
15-44	0.435	0.409	0.389	0.394	0.408
45+	0.168	0.123	0.131	0.132	0.123
Overall sex ratio, males/female	1.005	0.993	0.980	0.974	0.983

rate of population growth between 1945 and 1950 was used in matching the observed population with models. For 1961, an estimate of child mortality, obtained by extrapolating into the past from child mortality estimates for around 1970 (following the procedure described in the section, "Estimates of Child Mortality," below), was used to select model stable populations. For 1974, an estimate of child mortality was obtained by extrapolating forward from the same estimates. Stable populations based upon the "North" age pattern of mortality were used, in accordance with evidence from registered deaths that this regional pattern best represents mortality risks in Honduras (see the following section on vital registration).

Table 6 shows the proportions of the male population under each age, the implied male birth rates, and, for 1961 and 1974, the adjusted birth rates, making some allowance for increasing population growth. For 1950, two series of estimates are given, one based on the observed intercensal growth rate of 2.5 percent, the other based on a rate of 1.5 percent. The latter, obtained as the rate of growth in 1950 from a comparison of the age structure of deaths and the age structure of the population (see the section below on death registration), gives results clearly more consistent with those for later years, and the difference between the two provides a useful example of how sensitive the analysis is to the estimate of the growth rate that is used. Those series based on estimates of child mortality are somewhat less sensitive; for instance, the use of level 13 in the "North" family for 1974 instead of level 14.5 would simply add about a point to the birth rate, and two or three points to the death rate. It should be noted,

TABLE 6 Stable Population Analysis of Male Age Distribution, 1950, 1961, and 1974: Honduras

	1950			1961			1974		
Age a	$C(a)$[a]	Birth Rate b[b]	Birth Rate b[c]	$C(a)$[a]	Birth Rate b[d]	Adjusted Birth Rate $\hat{b}$[e]	$C(a)$[a]	Birth Rate b[f]	Adjusted Birth Rate $\hat{b}$[g]
5	.1601	38.1	44.9	.1926	50.0	50.4	.1868	46.4	46.4
10	.2924	37.4	46.5	.3597	53.1	54.0	.3505	48.8	49.4
15	.4146	38.9	49.9	.4886	53.1	55.9	.4924	51.0	52.4
20	.5163	38.9	49.7	.5840	51.4	56.0	.5985	50.9	53.2
25	.6059	39.4	49.9	.6651	50.4	55.8	.6808	50.1	53.4
30	.6785	38.8	48.4	.7314	49.4	55.3	.7412	48.5	52.7
35	.7387	37.9	46.1	.7896	49.0	55.2	.7927	47.2	52.3
40	.7945	38.0	45.4	.8392	49.0	55.1	.8397	46.8	52.5
Estimated Rates for Both Sexes (sex ratio at birth equals 1.05, sex ratio of population as reported)									
Birth rate		37.6	46.4			53.7			50.7
Death rate		12.6	30.7			19.2			14.5

[a] Proportion of male population under age a.
[b] Based on stable rate of growth of 2.5 percent.
[c] Based on stable rate of growth of 1.5 percent.
[d] Based on mortality level 12.0.
[e] Adjustment factor, k, for increase in rate of growth of .0220, $t = 17$ years.
[f] Based on mortality level 14.5.
[g] Adjustment factor, k, for increase in rate of growth of .0150, $t = 30$ years.

however, that not much confidence can be placed in the estimates obtained from stable population analysis of the 1950 age distribution. Even when a population growth rate of 1.5 percent is used, the estimate of the birth rate is only 46 per 1000, substantially lower than estimates for 1961 and 1974 and only marginally higher than the registered birth rate, prior to any adjustment, of 42 per 1000 for 1950. A comparison, age group by age group, of the 1950 and 1961 populations (see the next section) also indicates that one or the other is seriously distorted; consistency with estimates from other sources suggests that it is the 1950 age distribution that is wrong.

The set of estimates for 1950 based on a growth rate of 1.5 percent looks more plausible than that based on a growth rate of 2.5 percent, which gives implausibly low values of both fertility and mortality. The growth rate of 1.5 percent gives fertility estimates of the right order of magnitude, but implies very high mortality; mortality may very well have been high, but doubts about the quality of the age distribution itself render firm conclusions impossible. The estimates based on a growth rate of 1.5 percent per year correspond to an expectation of life at birth of about 34 years, around level 7 in the "North" family of the Coale-Demeny model life tables. The 1961 age distribution, showing high fertility and fairly high mortality, provides the most consistent set of estimates. The 1974 age distribution shows somewhat lower fertility and lower mortality; the relatively low birth rates obtained from the proportions under 5 and under 10 may be due to the effects of gradually declining fertility, but are more likely to be due to relative underenumeration of young children, in view of evidence that the 1974 census substantially underenumerated the total population (see the section below on completeness of enumeration). Estimates of the birth rate obtained from corrected registered births (shown in Table 10 below) agree reasonably well with the stable population estimates.

Estimation of the Birth Rate by Reverse Survival

Reverse survival of young children, to estimate births, and reverse projection of the total population, to estimate earlier population denominators, have been applied to the 1974, 1972, and 1961 populations classified by age group and sex. Mortality assumptions for five-year periods were obtained (see the section on estimates of child mortality), and an approximate population growth rate for the entire period was assumed; the value of the growth rate used has only a modest effect on the estimates of the birth rate. Estimated birth rates by sex and five-year period are shown in Table 7.

TABLE 7 Estimates of the Birth Rate Obtained by Reverse Survival: Honduras

Source	1951-1955[a]	1956-1960[b]	1959-1963[c]	1963-1967[d]	1964-1968[e]	1968-1972[f]	1969-1973[g]
1961 census							
Males	58.0	50.9					
Females	53.6	48.2					
1972 survey							
Males				54.6		49.2	
Females				50.6		45.2	
1974 census							
Males			56.8		52.7		47.0
Females			52.2		48.8		44.1

Note: Population denominators were obtained by assuming a constant rate of growth of 3.2 percent in all periods.

Mortality levels in "North" model life tables are as follows:

[a] 10.5
[b] 11.5
[c] 12.0
[d] 12.7
[e] 13.0
[f] 13.7
[g] 14.0

For each series, the birth rates are lower in the period immediately before the survey than in earlier periods, giving the impression of falling fertility. It may be concluded, however, that at least part of this apparent trend is spurious, since estimates for overlapping periods from different sources—for instance for 1956–1960 from the 1961 census and for 1959–1963 from the 1974 census—show the opposite trend. Omission of young children or exaggeration of their ages often reduces the relative size of the 0–4 age group. In support of some downward trend, however, it may be noted that the estimates obtained for the period immediately preceding each survey do decline by about 8 percent over a 13-year period, indicating that the birth rate has fallen, that the relative enumeration of the reported 0–4 age group has worsened, or that the mortality decline assumed in the calculations was not correct.

Completeness of Enumeration

In many of the techniques used in this study, vital rates calculated from registered events are compared with population characteristics observed at a census or survey. When such comparisons are made, the population denominators used in calculating the rates affect their values and so also

affect the estimates of completeness of registration. It is therefore important to try to establish the relative completeness of enumeration of the successive censuses so that a consistent benchmark may be established, with reference to which the completeness of registration may be estimated. The variability of population growth rates by period shown in Table 4 suggests that completeness of enumeration has varied from one census to the next in Honduras; the decline in the growth rate for the most recent intercensal period is also suspicious in view of the high fertility rates and declining mortality rates estimated in other parts of this study.

A recently derived method for estimating the relative completeness of enumeration of two censuses and the completeness of registration of intercensal adult deaths has been proposed by Preston and Hill (1980). They show that, in a closed population, for any cohort the ratios of cohort size at a first census to cohort size at a second census and of intercensal cohort deaths to cohort size at the second census are linearly related if completeness of both death registration and enumeration are constant by age. The intercept of the straight line indicates the relative enumeration completeness of the two censuses, and its slope indicates the relative completeness of death registration. This method has been applied to the 1950–1961 and 1961–1974 intercensal periods. Table 8 shows, as an illustration, the basic data for the 1961–1974 application, and Figure 2 shows the points and fitted straight lines for both males and females. The estimates of completeness of enumeration and of death registration after childhood relative to the 1961 population enumeration are shown in Table 9.

The estimates for the 1950–1961 period are clearly unsatisfactory. Adjustment of the 1950 population by the amount shown leads to an implausibly low rate of intercensal growth with a substantial sex differential (the growth rates would be 2.1 percent for males, 1.7 percent for females), and adjustment of the intercensal deaths by the amount shown results in implausibly high mortality, in some cases off the scale of the mortality levels of the Coale-Demeny model life tables. A comparison, age group by age group, of the 1950 and 1961 populations raises some doubts about the accuracy of age reporting in 1950. The youngest age groups, 0–4 and 5–9, show very high rates of intercensal growth, between 4.5 and 5.0 percent per year, while the oldest age groups show negative growth, the population over 70 declining by more than 2.0 percent per year. An explanation of such growth rates would require complicated and dramatic changes in levels and age patterns of mortality or fertility that must be regarded as unlikely.

The estimates obtained for the 1961–1974 period seem much more reasonable; underenumeration in 1974 relative to 1961 does not vary with

TABLE 8 Population by Sex and Age Group, 1961 and 1974, by Cohort Age in 1961, with Registered Intercensal Cohort Deaths: Honduras

Age Group in 1961	Population 1961, $P(1)$[a]	Population 1974, $P(2)$[a]	Registered Cohort Deaths 1961-1973, D	$P(1)/P(2)$	$D/P(2)$
Males					
5-9	156,760	116,927	4,788	1.3307	.0410
10-14	121,024	93,765	4,354	1.2811	.0464
15-19	89,485	70,272	4,715	1.2639	.0671
20-24	76,066	63,391	4,783	1.1910	.0755
25-29	62,212	56,109	4,711	1.1005	.0840
30-34	54,684	45,175	4,496	1.2015	.0995
35-39	46,526	36,658	4,214	1.2597	.1150
40-44	37,236	28,011	4,242	1.3194	.1157
45-49	30,687	23,416	4,600	1.3007	.1964
50-54	25,112	17,818	5,209	1.3988	.2923
55-59	18,035	10,646	5,597	1.6814	.5258
60-64	17,624	8,359	5,620	2.0925	.6724
Females					
5-9	150,867	129,559	4,089	1.1558	.0316
10-14	114,238	102,198	3,295	1.1092	.0322
15-19	94,688	75,957	3,282	1.2373	.0432
20-24	81,701	66,228	3,489	1.2244	.0527
25-29	68,125	59,164	3,834	1.1429	.0648
30-34	56,107	46,363	3,916	1.2011	.0845
35-39	48,872	38,311	3,597	1.2661	.0939
40-44	37,207	28,163	3,702	1.3113	.1315
45-49	30,845	23,797	3,984	1.2865	.1674
50-54	25,671	17,128	4,649	1.4876	.2714
55-59	18,202	11,434	5,291	1.5800	.4628
60-64	17,846	8,305	5,255	2.1328	.6328

[a] The populations have been moved back to the beginning of each year by using observed growth rates.

sex, male deaths are rather more completely registered than female deaths, the adjustment of the 1974 population gives more plausible intercensal growth rates (3.4 percent for males, 3.5 percent for females), and adjusted registered deaths give reasonable mortality levels (discussed in the section on vital registration). The 1961 census has therefore been adopted as the benchmark for this study, the 1950 enumerated population has not been adjusted for want of a reliable adjustment factor, and the 1974 population has been inflated by 11 percent, equally for each sex.

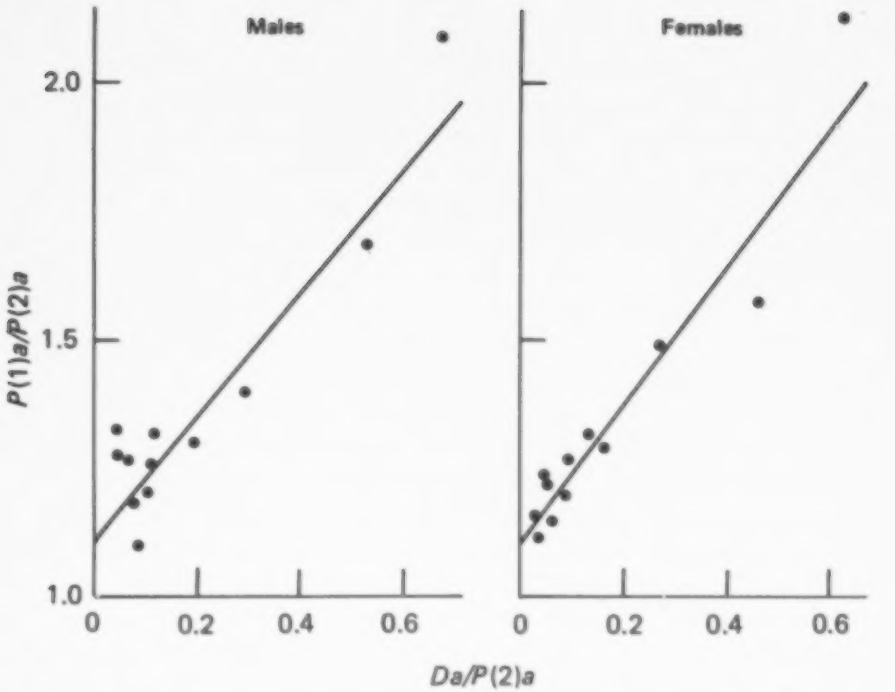

FIGURE 2 Cohort deaths as proportion of final cohort size plotted against initial cohort size as proportion of final cohort size, 1961–1974: Honduras.

An alternative explanation of the apparent population deficit in 1974 is net migration, since the technique used assumes a closed population. The effect of steady emigration from a cohort will be to reduce the size of the cohort by the amount of the emigration and also to reduce the cohort deaths by about half the proportionate amount of the net emigration.

TABLE 9 Estimates of Completeness of Enumeration and Death Registration, 1950-1961 and 1961-1974: Honduras

	Completeness in Relation to 1961 Census Enumeration of				
Sex	1950 Census	1951-1960 Registered Deaths	1961 Census	1961-1973 Registered Deaths	1974 Census
Males	0.92	0.30	1.00	0.83	0.90
Females	0.87	0.24	1.00	0.76	0.90

These effects will result in an underestimate of enumeration completeness of the second census relative to the first and an overestimate of registration completeness. However, these simple conclusions are confounded by the age pattern of migration and its heavy concentration among young adults; only those cohorts substantially affected by migration would be strongly distorted, and inspection of the points for those cohorts only would be expected to reveal whether migration had been an important factor or not.

Birthplace information from the 1974 census is not available, but in 1961 the foreign-born population was nearly 63,000, having increased from 33,000 in 1950. Information on those born in Honduras but enumerated in censuses elsewhere is rather difficult to obtain, since birthplace data are often not tabulated in sufficient detail or not published at all. Of those countries with data available, however, the United States had the largest number of people born in Honduras, about 19,000 in 1970; El Salvador had about 14,000 in 1971, and Guatemala nearly 10,000 in 1964. No figures are available for the other country bordering Honduras, Nicaragua, but the total number of foreign born enumerated in Nicaragua in 1963 was only about 5,000. Putting these scraps together and doubling them to allow for countries not included suggests that the number of people born in Honduras but living elsewhere in 1970 probably did not exceed 90,000; extrapolating forward from the foreign-born population of Honduras in 1961 (63,000), it seems reasonable to suppose that the number of foreign born in 1970 might also have been about 90,000. (Arrival and departure statistics, which cannot be considered reliable evidence for 1963–1967, showed a net loss of nearly 8,000 people, insufficient to account for the apparent population deficit in 1974.) Further, an examination, cohort by cohort, of intercensal survival rates does not show the pattern that would be expected from emigration. In general, then, the majority of the evidence does not support the possibility of substantial emigration between 1961 and 1974, although one piece of evidence that does support it comes from the 1970–1972 multiround survey: emigrants outnumbered immigrants by 2 to 1, giving a net emigration rate of 3 per 1000, enough to account for about half of the population deficit observed in 1974. One reason for not putting too much reliance on this finding is the fact that the number of people leaving the sample areas for other parts of Honduras also outnumbered those arriving from other parts of Honduras by a substantial margin (Somoza and Packer, 1975).

One special event that ought to be mentioned, since it is relevant to the question of migration between 1961 and 1974, is the so-called soccer war that took place between Honduras and El Salvador in July 1969. Population pressure in El Salvador is alleged to have resulted in

substantial migration to Honduras, causing tensions that culminated in a five-day war between the two countries. Some journalistic sources have claimed that as many as 300,000 Salvadorians had migrated to Honduras in the decade or two before 1969, though there is no confirmation for this estimate in the available statistics. It has also been claimed that as many as 200,000 of these immigrants left Honduras just before or after the war, though again there is no firm evidence to support that claim. Indeed, the registered births and deaths, which might be expected to show a sharp drop if 10 percent of the population suddenly left, show no sudden break in their trend in 1968, 1969, and 1970. One of the cease-fire provisions was that Salvadorians in Honduras were to be adequately treated; so again there is no reason to suppose that a large number were forced to return to El Salvador.

If the journalistic estimates of Salvadorian immigration are correct, the above estimates of underenumeration in 1974 may be too low. It seems unlikely that many of those immigrants returned to El Salvador after the 1969 war, but even if they did, only those who arrived in Honduras before the 1961 census would affect the estimates of relative census enumeration given above. The effect of the remaining migrants, arriving after one census but leaving before the next, would be to overestimate the completeness of death registration, since some of the deaths among them would probably be registered; the estimates of relative enumeration completeness would be little affected. Given the data available, there is no way of estimating the flow of Salvadorians to Honduras, though it seems unlikely that a large number returned suddenly to El Salvador around the time of the war. The estimates of relative underestimation of the 1974 census should be regarded as minimums since they assume a net immigration of zero.

COMPLETENESS OF VITAL REGISTRATION

Comparison of Registered Births with Average Number of Children Ever Born

Registered births by age of mother are available for Honduras from 1951 to 1974; information on average number of children ever born by age of mother is available from the retrospective sample survey of 1972 and from a 10-percent sample drawn from the 1974 census.

Two methods of analysis are available for estimating the completeness of registration of births by comparison with data on children ever born by age group of mother. The first method (Brass, 1964) cumulates age-specific registered birth rates and, after interpolation, compares the totals (denoted

TABLE 10 Estimates of Completeness of Birth Registration Based on Comparisons with Lifetime Fertility: Honduras

Part A Period Estimates 1972 and 1974

Age	Registered Births	Estimated Female Midyear Population	Observed Fertility Rate f	Reported Average Parity P^a	Comparable Cumulated Current Fertility F	Estimated Completeness of Registration F/P
1972						
15-19	23,371	153,642	.1521	0.288	0.328	1.140
20-24	34,594	124,966	.2768	1.671	1.449	0.867
25-29	26,519	93,349	.2841	3.382	2.871	0.849
30-34	18,412	75,050	.2453	4.971	4.201	0.845
35-39	13,143	69,271	.1897	6.242	5.306	0.850
40-44	5,114	55,461	.0922	7.202	5.999	0.833
45-49	1,090	46,257	.0236	7.296	6.289	0.862
1974						
15-19	24,268	167,504	.1449	0.288	0.309	1.073
20-24	36,781	134,813	.2728	1.600	1.406	0.879
25-29	27,125	98,747	.2747	3.227	2.790	0.865
30-34	18,857	79,049	.2385	4.888	4.084	0.836
35-39	12,961	73,720	.1758	6.132	5.131	0.837
40-44	5,137	59,556	.0863	6.918	5.777	0.835
45-49	1,037	49,726	.0209	7.163	6.045	0.844

Part B Cohort Cumulation to 1974

Age of Cohort in 1974	Cumulated Cohort Fertility	Average Children Ever Born	Estimated Completeness of Registration for Cohort
15-19	0.253	0.288	0.931
20-24	1.342	1.600	0.861
25-29	2.740	3.227	0.848
30-34	4.135	4.888	0.841

[a] The data for 1972 are from the 1972 survey, after adjustment by the El Badry technique for false "not stateds." The data for 1974 are from a 10-percent sample; no adjustment for false "not stateds."

by *F*) by age group with the average number of children ever borne (denoted by *P*) by the women in the corresponding age groups. Assuming that younger women correctly report their children ever born and that the failure to register births does not vary with age, the age pattern of fertility obtained from registered births is accepted, but the level of fertility is adjusted to give the observed average parities for the younger women. One assumption of this method is that fertility is not changing, and a marked trend by age group of women in the estimates of registration completeness obtained would be a warning that the assumptions of the method may not have been met.

The second method of analysis does not require the assumption of constant fertility, but it does require more data. Age-specific fertility rates are calculated from registered births for 20 years or so before the census or survey providing information on children ever born. The fertility rates for each calendar year are split up to estimate single-year rates, which are then cumulated by cohort, selecting cohorts to coincide with conventional five-year age groups at the time of the census or survey. Completeness of registration for the period is then estimated by the ratio of the cumulated registered birth rates to the average number of children ever born per woman in each five-year age group reported by the census or survey. In practice, the cumulation is carried out only up to the 30–34 age group, since the registration data needed for women older than that extend an excessive length of time into the past. The method is not affected by changing fertility since cohorts of women are followed through their reproductive lives, but it is affected by changing completeness of birth registration: if registration is improving over time, the estimates of completeness based on the reports of older women will be of average completeness over their reproductive lives, thus being below the level of completeness at the time of the census or survey.

The first of the two methods, generally called the *P/F* ratio method, has been applied to the data for both 1972 and 1974, the two years for which data on children ever born are available. The second method has been applied only to 1974 because the observed average parities for 1972 and 1974 are so similar. The population denominators used were calculated using the inflated 1974 population, after allowing for relative underenumeration. The applications are shown in Table 10.

Excluding the estimates based on the generally unreliable 15–19 age group, the estimates of registration completeness are rather consistent, all falling within the range of 83–87 percent (see Table 10). The average completeness estimated by the *P/F* ratio method for both 1972 and 1974 is 85 percent, as is the average completeness for cohorts to 1974; all these

completeness estimates are relative to the completeness of enumeration of the 1961 census. A best estimate of 85 percent, the median of all the estimates except those for the 15–19 age group, is accepted, implying that registered births should be adjusted by a factor of 1.18 to allow for underregistration. The cohort cumulation procedure does not suggest that birth registration has improved much (improving registration would show up in the form of declining estimates of completeness as cohort age increases); the average level of completeness estimated for 1974 is the same as that for 1972, but the 1972 average parities come from a very much smaller sample and also incorporate an adjustment for nonresponse. It is therefore concluded that the completeness of birth registration has remained more or less constant during the recent past. Table 11 shows age-specific fertility rates for selected years obtained by adjusting registered births by a factor of 1.18 and calculating denominators for intercensal years by assuming a constant intercensal growth rate for each age group.

The very high fertility rates estimated for the early 1960s may in part result from a bunching of delayed registrations in that period, since births are recorded by year of registration rather than occurrence. A piece of circumstantial evidence that supports this idea is provided by the mean age of the fertility schedule: it increases steadily to the mid-1960s and then declines somewhat. It is possible that registration among older women improved or that the age pattern of fertility changed, actually got somewhat older, but it is also possible that delayed registrations, recording age of mother at the time of registration rather than at the time of the birth of the child, created higher recorded ages of mother. Evidence from the 1970–1972 multiround survey, not affected at all by delayed registration, gives an estimate of 29.3 years for the mean age of the fertility schedule, virtually the same as that obtained from registered births in the same period. This finding is consistent with, though of course it does not prove, the theory that the fertility rates for the early 1960s were somewhat inflated by delayed registration, whereas the more recent ones were little affected.

The sequence of total fertility rates obtained by inflating registered births by 1.18, shown in Figure 1, suggests that fertility may have been slightly lower in 1973 and 1974 than in 1972, since either the registration of births was somewhat less complete in the latter two years than earlier, for which we have found no evidence, or fertility rates averaged some 4 percent lower in these two years than in 1972. However, the recent total fertility rates show some fluctuations, and the level for 1970 is in fact lower than that for 1973 or 1974, so it would be unwise to conclude that a fertility decline has recently started, though it is a possibility.

TABLE 11 Age-Specific Fertility Rates Based on Adjusted Registered Births, Selected Years: Honduras

	Age-Specific Fertility Rates[a]						
	1951	1956	1961	1965	1969	1972	1974
Age Group							
15-19	.1611	.1412	.1642	.1590	.1644	.1794	.1710
20-24	.3274	.3313	.3458	.3215	.3172	.3266	.3219
25-29	.3487	.3510	.3611	.3481	.3363	.3352	.3241
30-34	.2734	.2779	.3108	.3214	.3041	.2895	.2814
35-39	.1449	.1947	.2329	.2380	.2211	.2238	.2074
40-44	.0773	.0761	.1005	.1064	.1031	.1088	.1018
45-49	.0154	.0181	.0350	.0455	.0231	.0278	.0247
TFR	6.74	6.95	7.75	7.70	7.35	7.46	7.16
Mean age at childbearing	28.3	28.8	29.3	29.6	29.2	29.1	29.0
Birth rate (census years)	50.9[b]		54.1				49.9

[a] Births registered in year shown inflated by 1.18 for underregistration; 1974 population inflated by 1.11.

[b] One year after the 1950 census; population estimated by interpolation between 1950 and 1961 populations.

Estimates of the Completeness of Death Registration

Brass (1975) and Preston (Preston and Hill, 1980) have devised methods of estimating the completeness of registration of deaths that occur after childhood. Both methods are based on the assumption that the population under study is stable: the Brass method uses information on the age structure of deaths and the age structure of the population, whereas the Preston method uses information on the age structure of deaths and an estimate of the stable rate of natural increase.

Registered deaths by five-year age group and sex are available from 1951 to 1974, but census age distributions are available only for 1950, 1961, and 1974. For the application of the Brass technique, the 1950 census age distribution was moved forward to mid-1951 using the observed intercensal growth rate. The 1961 enumerated population was also moved forward to midyear, and the 1974 population was both moved to midyear and inflated by a factor of 1.11. The Preston method has been applied to the same three years.

Estimates of completeness of registration, with a stable rate of population growth, are shown in Table 12. For the Brass method, the rates of growth are estimated as a part of the method; for the Preston method, the growth rates are assumed. The variant of the Brass technique applied uses successive age groups rather than successive point ages to provide "birth" rates of the population over given ages, as recommended by Rachad (1977); straight lines were fitted to observed points using a trimmed mean procedure by which the three lowest and the three highest points were increasingly underweighted. The graphs obtained by applying the Brass techniques are shown in Figure 3.

Consistency is not a notable feature of the estimates shown in Table 12. The estimates of completeness vary by at least 25 percent, and it is clear that the Preston results depend critically on the estimates of the growth rate; when the growth rates estimated by the Brass technique are used in applying the Preston method, the completeness estimates are almost identical, except in 1974. The Brass estimates show low completeness and rather slow growth around 1951, improved registration (especially for females) and doubled growth rates by 1961, and 80 percent or higher completeness for both sexes with high growth rates in 1974, consistent with the intercensal rates obtained by inflating the 1974 population totals. The 1951 estimates, of course, depend on the 1950 age distribution, which has been shown to be suspect. The Preston estimates of completeness of registration rise in some cases and decline in others between 1961 and 1974, depending on the rate of growth. In view of the variations by sex, by method, and by period, it is difficult to reach any firm conclusions about

TABLE 12 Estimates of Completeness of Death Registration, by Sex, 1951, 1961, and 1974: Honduras

Method	1951		1961		1974	
	Completeness	Rate of Growth[a] (percent)	Completeness	Rate of Growth[a] (percent)	Completeness	Rate of Growth[a] (percent)
Males						
Brass	0.424	1.4	0.701	2.9	0.795	3.3
Preston[b]	0.684	(2.8)	0.678	(2.9)	0.564	(2.6)
Preston[c]	n.a.	n.a.	0.778	(3.2)	0.785	(3.4)
Preston[d]	0.425	(1.4)	0.678	(2.9)	0.752	(3.3)
Females						
Brass	0.459	1.5	0.782	3.2	0.844	3.6
Preston[b]	0.722	(2.8)	0.642	(2.8)	0.536	(2.7)
Preston[c]	n.a.	n.a.	0.805	(3.3)	0.758	(3.5)
Preston[d]	0.456	(1.5)	0.771	(3.2)	0.791	(3.6)

Note: n.a. means not available.

[a] Growth rates in parentheses are assumed; growth rates not in parentheses are estimated by the method.

[b] Using average of growth rates observed on either side of year shown, except for 1974, which used the observed intercensal growth rate for 1961-1974.

[c] As in footnote *b*, but after adjusting 1974 total by 1.11 for underenumeration.

[d] Taking the rate of growth from the Brass estimate.

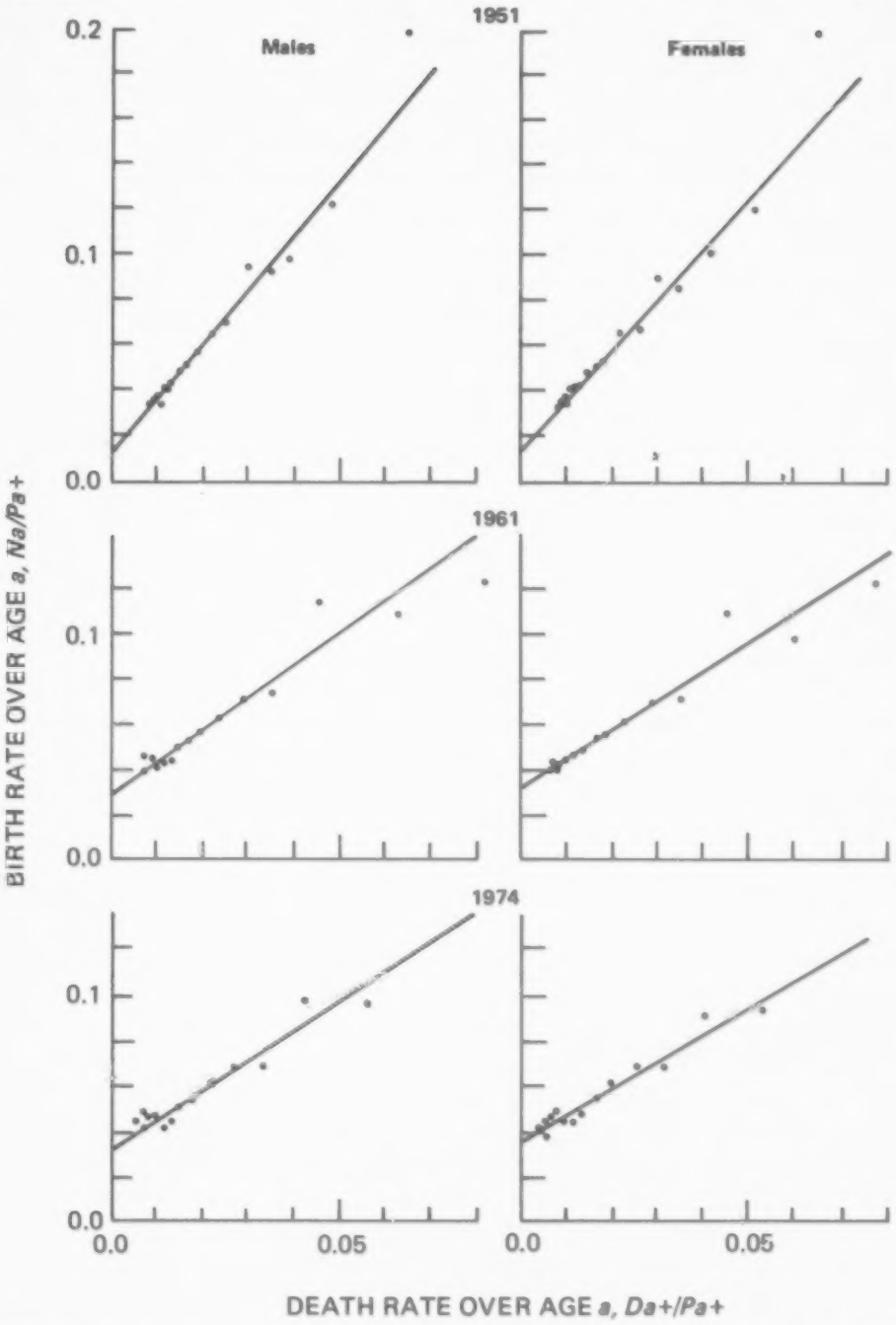

FIGURE 3 Applications of the Brass growth balance method, 1951, 1961, and 1974: Honduras.

the level of completeness of registration of deaths after childhood beyond saying that registration is incomplete, that it was more incomplete in 1951 than in 1961 or 1974, that in 1974 completeness was probably within the range of 75–85 percent, and that it may have been in the range of 70–80 percent in 1961. It is interesting to bear in mind that the intercensal cohort survival method (covered in the previous section) gave estimates of completeness of registration of deaths after childhood for the 1961–1974 intercensal period of 83 percent for males and 76 percent for females. The intercensal method does not, of course, make any assumptions about stability.

It should be emphasized that the estimates being discussed here are of completeness of registration of deaths after early childhood; registration of infant deaths in Honduras is much less complete (as is discussed below).

Registered deaths provide information not only about the level of mortality but also about its age pattern. If it can be assumed that completeness of registration is approximately constant by age, deaths recorded by age and sex can be adjusted by the reciprocal of the estimated level of completeness, age-specific mortality rates can be calculated for each sex, and these estimated rates can be compared with those from model life table systems of similar mortality levels in order to select for subsequent use a model life table system with a suitable age pattern of mortality. The necessary information, namely deaths by age group and sex, and population denominators are available for Honduras for 1961 and 1974. Deaths were inflated to allow for estimated completeness of adult death registration of 83 percent for males and 76 percent for females; the 1974 population was increased by a factor of 1.11 for both sexes to allow for relative underenumeration in 1974. Age-specific mortality rates were then calculated, separately by sex. Corresponding death rates from a standard level life table from each Coale-Demeny regional family were found, and differences were calculated for each age group. Relative differences, expressed as a proportion of the model values, are shown graphically by age (for age groups after infancy) in Figure 4. The standard level used was chosen to give mortality rates approximately equal to the observed values for the central age range: level 14 was chosen for 1961 and level 17 for 1974.

Figure 4 calls attention to several important points. Perhaps the most obvious feature is the similarity between the deviations for 1961 and those for 1974; the observed mortality rates are thus consistent for the two years, though of course the reason for this consistency may be similar data errors for both years. Further, the deviations from the model mortality patterns are rather large, particularly in late childhood and middle age. The variation in the deviations by family also indicates that in order to

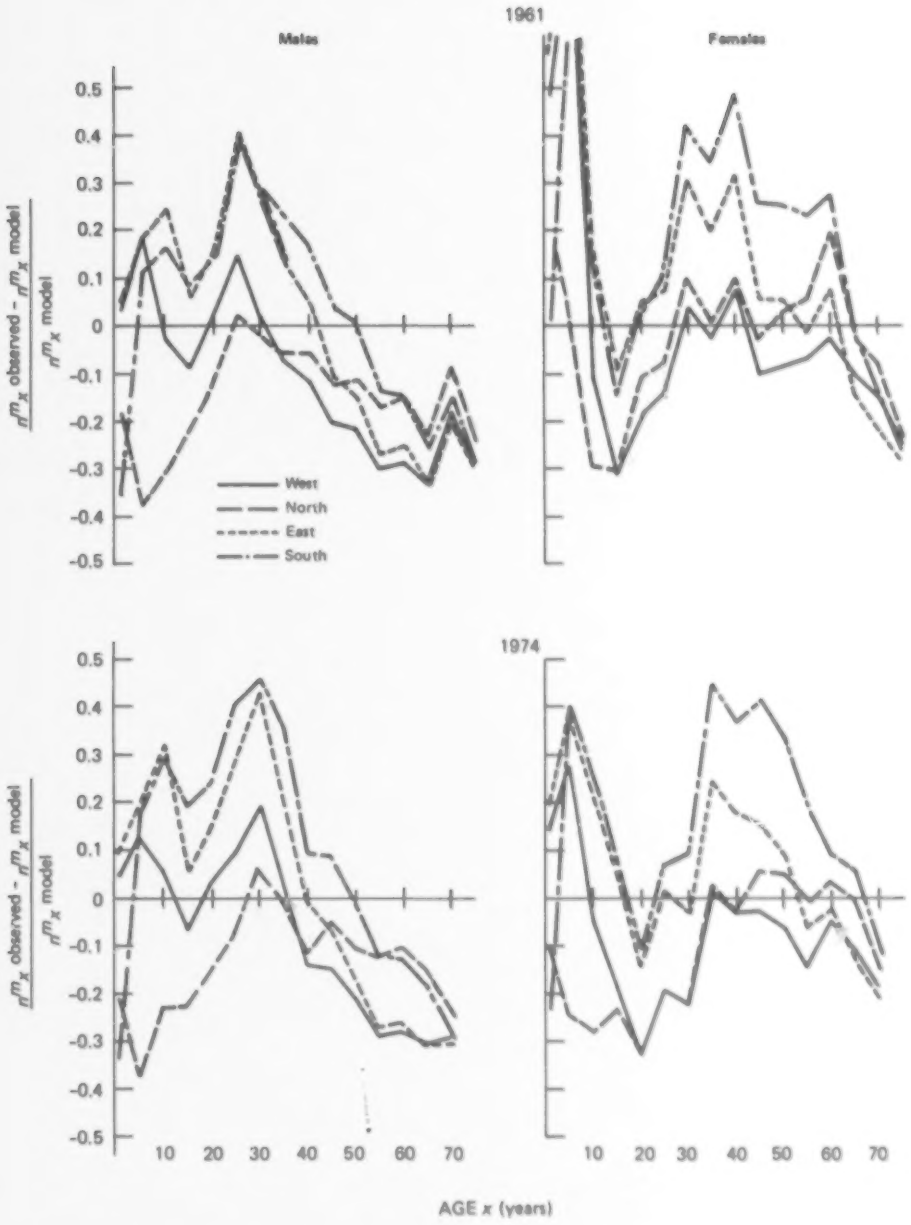

FIGURE 4 Relative deviations of observed age-specific mortality rates from model values, 1961 and 1974: Honduras.

TABLE 13 Comparison of Current and Retrospective Fertility, 1972 Survey: Honduras

Age Group of Women	Female Population	Recorded Births	Children Ever Born[a]	Observed Fertility Rate	Average Parity[b]	Cumulated Current Fertility	Adjustment Factor *P/F*
All Births							
15-19	1586	234	455	.1475	0.288	0.381	0.756
20-24	1292	394	2153	.3050	1.671	1.645	1.016
25-29	979	318	3302	.3248	3.382	3.251	1.040
30-34	790	229	3916	.2899	4.971	4.780	1.040
35-39	757	174	4712	.2299	6.242	6.067	1.029
40-44	585	73	4201	.1248	7.202	6.900	1.044
45-49	501	11	3645	.0220	7.296	7.216	1.011
First Births Only							
15-19	1586	134	323	.0845	0.204	0.257	0.792
20-24	1292	96	917	.0743	0.710	0.667	1.065
25-29	979	19	868	.0194	0.887	0.857	1.035
30-34	790	5	732	.0063	0.927	0.912	1.016
35-39	757	—	714	—	0.943	0.923	1.022
40-44	585	—	555	—	0.949	0.923	1.028
45-49	501	—	471	—	0.940	0.923	1.018

[a] Reported.
[b] After application of the El Badry technique to estimate true "not stateds" (0.28 percent of all women).

represent the true age-specific mortality rates properly, it is important to select the right model; at most ages, some deviations are positive and some negative. All observed male rates are below model ones after age 50, suggesting that either the numerators, registered deaths, are too small, or the denominators, male population, are too large, or, of course, a combination of both. Female rates are not consistently too low until after age 60 in 1961 or age 70 in 1974. It is interesting to note that although the male and female patterns are broadly similar, there do seem to be systematic differences by sex. For example, the female observed rates are relatively low around age 20, have a peak in the age group 5–9, and reach another peak around age 40; for males, the first peak is less marked and later, the subsequent trough is less marked, the main peak comes around 30, and the shortfall after age 50 is much more marked. Once again it should be stressed that there is no reason to suppose that these patterns reflect real differences in the age pattern of mortality by sex rather than consistent age patterns of error that are different by sex.

The final choice of a family cannot be made with much confidence from Figure 4, though the choice seems to lie between "North" and "West." When relative errors are summed for all ages, the "North" family gives a somewhat lower sum than the "West" family in all four cases, and so "North" has been selected.

RETROSPECTIVE SURVEY INFORMATION ON FERTILITY

The 1972 retrospective survey collected information on children ever born by age of mother and on the date of each woman's most recent live birth. Tabulations are available (Hill et al., 1977) that make it possible to compare current fertility, that is, births by age of mother in the year before the survey, with lifetime fertility, that is, children ever born by age of mother, both for all births, regardless of order, and for first births only. These survey data for 1972 thus provide fertility information that is entirely independent of the vital registration system. Table 13 shows the internal comparison of the survey data for all births and for first births.

Excluding the 15–19 age group, for which the interpolation procedure used is too crude to give reliable results, the ratios of current to retrospective fertility experience are very consistent, show no trend with age, and give an average adjustment factor for current fertility of 1.03. This adjustment factor is close to what one would expect if all births were reported with no timing error, given the form of the question, which was date of most recent birth. A subsequent tabulation of births in the last year would count multiple births of a woman with two single births in the year only once, the combined effect of which might be to reduce the number of

TABLE 14 Age-Specific Fertility Rates, 1972, from Adjusted Registration and Adjusted Survey Data: Honduras

Source	Age Group of Women							TFR
	15-19	20-24	25-29	30-34	35-39	40-44	45-49	
Adjusted registered births	.1794	.3266	.3352	.2895	.2238	.1088	.0278	7.46
Adjusted survey data	.1833	.3162	.3309	.2942	.2260	.1180	.0204	7.44

births recorded by some 2 or 3 percent. The ratios of current to retrospective fertility for first births only are somewhat more erratic, though the average, once again excluding the 15–19 age group, is also 1.03. Given the general consistency of the adjustment factors with age and birth order, considerable confidence can be placed in a set of fertility rates obtained by inflating the observed rates by 1.03 and adjusting the rates by half a year to coincide with conventional age groups, the women having been half a year younger, on average, at the time of a reported birth than at the time of the survey. Adjusted rates are shown in Table 14, together with the rates calculated for 1972 from adjusted registered births. The two sets of rates are compared graphically in Figure 5. The two distributions are very similar and give total fertility rates that are practically identical. This close agreement provides powerful confirmation for the general level of fertility in 1972.

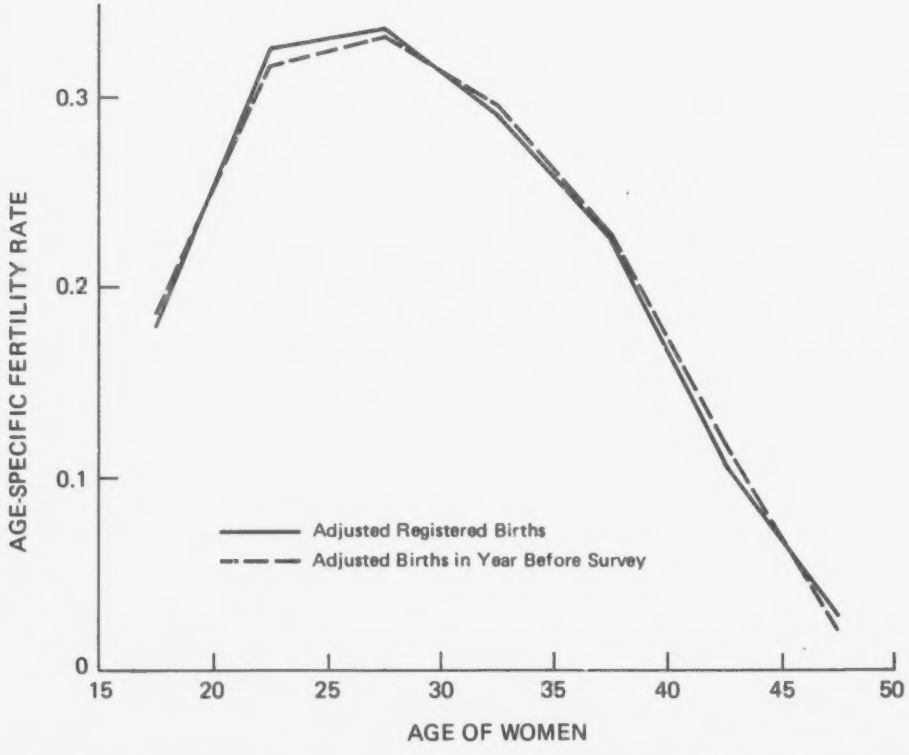

FIGURE 5 Age-specific fertility rates from adjusted registered births and adjusted survey data: Honduras.

INDIRECT METHODS FOR MORTALITY ESTIMATION

Estimates of Child Mortality

Child mortality can be estimated from information on the proportion dead among children ever borne by women in given age groups (Brass, 1964; Trussell, 1975). Such information is available for Honduras from two sources, the 1972 retrospective sample survey, and a 10-percent sample tabulation of the 1974 census. Several methods have been proposed for converting the proportions dead among children ever born to women of given age groups into probabilities of dying by exact ages of childhood, but the results given by the various methods do not in general differ greatly. A method proposed by Trussell, who used regression analysis to study the relationships between proportions dead and mortality risks in model situations, described in a technical manual (National Research Council, 1981), has been used here. In accordance with the evidence about the age pattern of mortality discussed above, the version of the Trussell method based on the "North" family of regional model life tables (Coale and Demeny, 1966) was used. Reported proportions dead by age group of mother, and derived child mortality estimates, are shown in Table 15. The probabilities of dying by exact ages of childhood have also been converted into estimates of mortality level in the "North" family of the Coale-Demeny model life tables.

TABLE 15 Child Mortality Estimates from Data on Children Dead Among Children Ever Born, 1972 and 1974: Honduras

Age Group of Women	Proportion of Children Dead	x	${}_xq_0$	Equivalent Mortality Level ("North" Models)	Years Prior to Survey (t^*)
1972 Survey					
20-24	.1602	2	.1579	12.4	2.4
25-29	.1914	3	.1801	12.3	4.4
30-34	.1956	5	.1912	13.1	6.5
1974 Census					
20-24	.1399	2	.1370	13.7	2.5
25-29	.1446	3	.1359	14.7	4.4
30-34	.1724	5	.1687	14.1	6.3

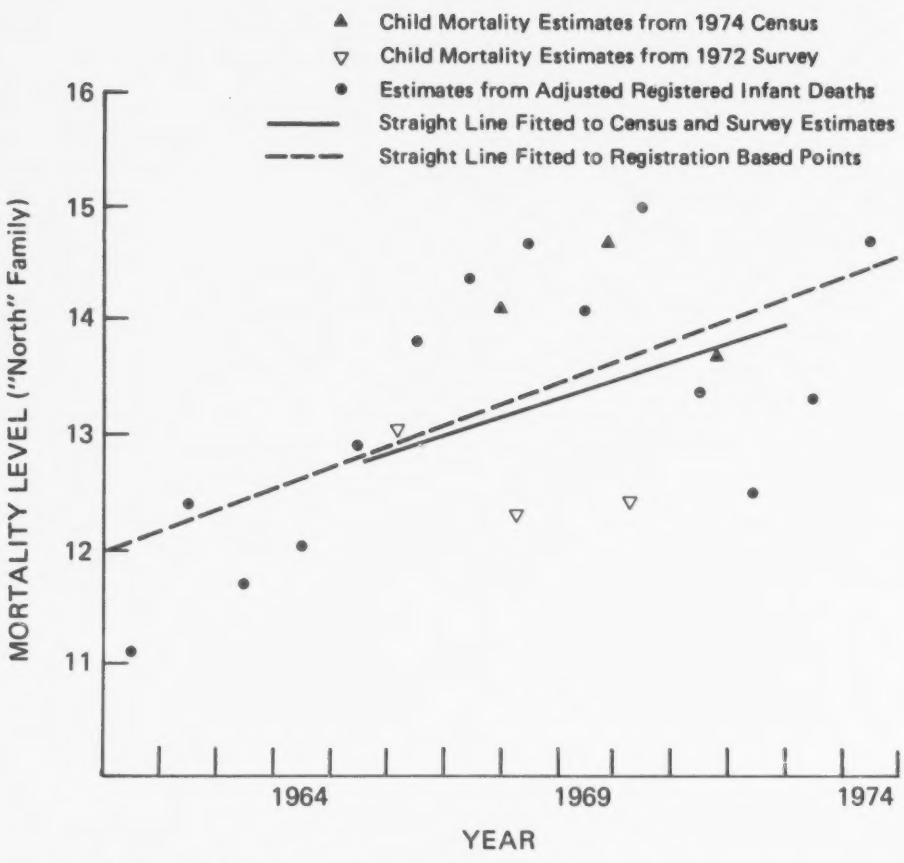

FIGURE 6 Levels of child mortality estimates in "North" family of model life tables by time period, 1961–1974: Honduras.

These estimates of child mortality are derived from retrospective reports of women about all their children, whose births were distributed over a period prior to the survey, the length of the period increasing with the average age of the women. The mortality experience represented by the proportion dead is an average of mortality over a period, and the mortality estimates obtained refer to some time in the past. If mortality has been constant, the time reference of the estimates does not matter, but if mortality has been changing, it is useful to be able to pinpoint the period to which the various mortality estimates refer. By assuming that mortality risks have been changing linearly over the period prior to the survey, it is possible to estimate the point to which each estimate refers, and a procedure for doing this has been devised by Coale and Trussell (National

Research Council, 1981). The estimated time location of each estimate, in terms of years before the survey, is shown in Table 15; the estimates are plotted as triangles in Figure 6.

The results obtained from the census and the survey seem to be inconsistent. The estimates of mortality levels in the "North" family of model life tables obtained from the survey are at least one level lower than those obtained from the census, the average difference being 1.6 mortality levels, equivalent to a difference in expectation of life at birth of nearly four years. As Figure 6 shows, although the reference periods of the estimates overlap, the levels obtained from the census are clearly above the levels obtained from the survey, so declining mortality cannot explain the difference. In both cases the data come from samples, and sampling error may explain much of the difference; if so, the census sample should be preferred since it is 10 times the size of the survey sample. Neither source, however, gives estimates that show a clear trend in child mortality with time; in fact, if anything, the estimates from each source seem to show increasing mortality, so it seems likely that some sort of reporting error is involved.

In an attempt to estimate a trend in child mortality, the six points were divided by period into two groups of three and a line drawn through the midpoints of the two clusters; this trend line, shown as a solid line in Figure 6, has a slope indicating an improvement in child mortality of 0.13 of a level per year. In view of the dispersion of the results, however, one cannot have much confidence in this trend estimate, but there is an additional piece of information. Infant mortality rates can be calculated from registered births and infant deaths, and although the level of such estimates will be grossly distorted by omission, both of births but more importantly of deaths, the trend will not be distorted unless completeness of registration changes. Infant mortality rates were calculated using registered events for each year from 1961 to 1974, and the average rate over the period was then calculated. The adjustment factor necessary to equate this rate with the estimate of infant mortality obtained for the beginning of 1968 from the mortality level trend line based on the indirect techniques was calculated. This factor, 2.81, was then applied to the registered infant mortality rates, and the implied levels in the "North" model life tables of the adjusted rates were found. These calculations are summarized in Table 16, and the levels are plotted as solid circles in Figure 6. The fluctuations are wild, but the levels do seem to show an upward trend; a straight line fitted by least-squares regression gives an annual improvement of 0.19 of a level per year, as shown by the dashed line in Figure 6. Only 41 percent of the variance of the points is explained by this line, however, so the confirmation is not very powerful, but the rate

TABLE 16 Births, Deaths, Observed and Adjusted Infant Mortality Rates, 1961-1974: Honduras

Year	Registered		Infant Mortality Rate		Mortality Level[b] Adjusted Rate ("North" Family)
	Births	Infant Deaths	Observed (per thousand)	Adjusted[a] (per thousand)	
1961	85,842	4,283	50	140	11.1
1962	92,128	4,020	44	123	12.4
1963	93,649	4,400	47	132	11.7
1964	100,315	4,564	45	128	12.0
1965	99,871	4,116	41	116	12.9
1966	100,266	3,790	38	106	13.8
1967	102,606	3,644	36	100	14.4
1968	107,302	3,650	34	96	14.7
1969	108,306	3,951	36	103	14.1
1970	107,121	3,559	33	93	15.0
1971	117,430	4,637	39	111	13.4
1972	122,267	5,260	43	121	12.5
1973	121,246	4,827	40	112	13.3
1974	126,166	4,301	34	96	14.7

[a] Observed rate times 2.81.

[b] Assuming sex ratio at birth of 105 males per 100 females.

of improvement agrees reasonably with that found from the indirect estimation procedure.

Infant mortality rates estimated from incomplete registration data will vary with changes in completeness of registration of either births or deaths. If birth registration improves while infant death registration remains constant, infant mortality will appear to fall, while if birth registration gets worse, infant mortality will apparently rise. However, if birth registration gets worse, it may be precisely those infants who die whose births are not registered and whose deaths will not be registered either; in this case, the registration of infant deaths will get worse, and infant mortality will apparently fall. In Honduras, however, there is no reason to suppose that completeness of birth registration has changed much since the early 1960s, so changes in infant death registration completeness are the most likely source of error. The decline in infant mortality discussed above could result from a decline in infant death registration or from more rapidly declining infant mortality being partially masked by improving infant death registration. The weak agreement of the trends obtained directly and indirectly suggests that the observed pattern may approximate the true one.

TABLE 17 Proportions with Surviving Mother by Age Group and Derived Estimates of Adult Survivorship, 1972 and 1974: Honduras

Age Group of Respondents	Age N	1972 Survey		1974 Census	
		Proportion with Mother Surviving	Female Survivorship Probability $l(25+N)/l(25)$	Proportion with Mother Surviving	Female Survivorship Probability $l(25+N)/l(25)$
15-19	20	0.929	0.925	0.930	0.927
20-24	25	0.877	0.875	0.882	0.879
25-29	30	0.809	0.813	0.814	0.818
30-34	35	0.713	0.723	0.721	0.731
35-39	40	0.596	0.604	0.610	0.620
40-44	45	0.504	0.506	0.498	0.500
45-49	50	0.389	0.371	0.387	0.369

Note: Mean age of childbearing: 26.92 years.

It is concluded, therefore, that child mortality has been declining in the recent past, the probability of dying by age 5 decreasing from about 0.247 in 1961 to about 0.186 in 1974. It is clear that infant deaths are very heavily underregistered; if these estimates of child mortality are correct, the completeness of infant death registration relative to birth registration is only 36 percent, and since birth registration is only estimated to be some 84 percent complete, the overall completeness of infant death registration is only 30 percent, three times worse than the completeness of adult death registration. Reasonable confidence can be placed in the general level of these child mortality rates, but the estimates of trends are much less soundly based, given the possible biases in the infant mortality rates obtained from registration data and the lack of consistency of the indirect estimates.

Adult Female Mortality

Techniques have been developed for obtaining estimates of adult survivorship from information on survival of mother or father (Brass and Hill, 1973; Hill and Trussell, 1977). The basic method is based on the fact that the parents of a particular respondent are known to have been alive at the time of conception (in the case of the father) or birth (for the mother) of the respondent. The parents were then exposed to the risk of dying for a period equal to the respondent's age (mothers) or age plus gestation period (fathers). The proportion of respondents of a particular age (or, usually, in a particular age group) with a surviving parent is therefore an indicator of adult survival probabilities. Models have been used to study the relationship between survival probabilities and proportions with surviving parents by age group, and methods for converting the latter into the former have been devised.

In Honduras, information on survival of mother is available from the 1972 retrospective survey and from a 10-percent sample of the 1974 census. Adult survivorship probabilities were calculated from the proportions with surviving mother using regression constants calculated by Hill (National Research Council, 1981). One of the independent variables used in the regression technique is the mean age of childbearing in the population; in both applications, this mean was calculated using information on the age pattern of births in the year before the 1972 survey, the 1974 registered births by age not being used for this purpose because of suspicions about their age pattern. Table 17 shows the proportions not maternally orphaned in the age range 15–49 and estimates of female survivorship from age 25 for both the 1972 survey and the 1974 census. The proportions with surviving mother are very consistent between the

TABLE 18 Logit Life Table Constants α and β Calculated from Survivorship Probabilities Shown in Table 17: Honduras

	1972			1974		
	$l(25+N)/l(25)$	α	β	$l(25+N)/l(25)$	α	β
Age N						
20	0.925	−0.170	0.673	0.927	−0.187	0.678
25	0.875	−0.041	0.787	0.879	−0.065	0.785
30	0.813	0.047	0.865	0.818	0.025	0.865
35	0.723	0.140	0.947	0.731	0.114	0.944
40	0.604	0.215	1.013	0.620	0.177	0.999
45	0.506	0.187	0.988	0.500	0.190	1.010
50	0.371	0.181	0.983	0.369	0.176	0.998
Female $l(2)$		0.866			0.871	
Mean		0.080	0.89		0.061	0.90
Median		0.140	0.95		0.114	0.94

two sources, as are the survivorship estimates, these being in most cases slightly higher from the 1974 data than from the 1972 data, consistent with the possibility of declining adult mortality.

There are several ways in which adult and child mortality estimates can be linked together to provide a complete life table, and one of the most convenient is the logit system (Brass, 1975). This system proposes that a life table can be defined in terms of some standard life table in such a way that

$$Y(a) = \alpha + \beta YS(a),$$

where α and β are constants, $Y(a)$ is the logit of $l(a)$, the probability of surviving to age a, and $YS(a)$ is the logit of the probability of surviving to age a in the standard life table. The logit of a probability p is defined as $1/2 \log [(1 - p)/p]$. The constant α can be interpreted as a measure of the level of mortality relative to the standard, and β can be interpeted as a shape parameter, determining the relationship between child and adult mortality relative to that of the standard. The logit system provides a useful way of looking at the consistency of adult mortality estimates obtained from orphanhood data. Given an estimate of survivorship to age 2, $l(2)$, each adult survivorship ratio $l(25 + N)/l(25)$ defines a unique pair of α and β values for any given standard and, although the values of α and β cannot be determined explicitly, iteration techniques can be used to obtain values of any required precision. In the case of Honduras, the standard used is a Coale-Demeny "North" family model life table, level 16, for females. An estimate of $l(2)$ for females, referring to a period five years before the date of the survey, was obtained by finding the mortality level for the required date from the trend line in Figure 6 and finding the female $l(2)$ corresponding to that level. An estimate for five years before the survey was used because of the fact that orphanhood data reflect deaths throughout a lengthy exposure period (data for young children, reflecting short exposure periods, are normally not usable because the reported incidence of orphanhood is implausibly low, perhaps because young orphans are adopted by relatives who are then recorded as the true, and of course surviving, parents). Estimates of α and β for each value of $l(25 + N)/l(25)$ are shown in Table 18; although they are extremely consistent between surveys, the internal consistency is not impressive, the values of β showing a marked tendency to increase with age of respondent. In general terms, the level of mortality, as measured by α, falls from 1972 to 1974, though this measure is largely determined by the assumed $l(2)$; the age pattern of mortality, however, as measured by β, has not changed measurably, adult mortality being shown to be somewhat lower, in relation to child mortality, than in the "North" level 16 standard. Declining

TABLE 19 Estimation of Adult Male Survivorship from Proportions of Ever-Married Women with Surviving First Husband, 1972: Honduras

	Proportion of Ever-Married Women with Surviving First Husband	N	Male Probability of Surviving $l(N)/l(20)$	Logit Life Table Constants ($l(2)$ Male = .846)	
				α	β
Age Group of Women					
25-29	.9498	25	.9650	0.181	0.990
30-34	.9303	30	.9426	0.052	0.866
35-39	.8601	35	.8905	0.207	1.015
40-44	.8496	40	.8805	0.060	0.874
45-49	.7785	45	.8316	0.109	0.921
50-54	.7237	50	.7969	0.076	0.890
55-59	.6900	55	.7845	−0.031	0.787
Mean				0.094	0.91
Median				0.076	0.89

Note: Singulate mean age at marriage is 24.3 for males and 20.1 years for females.

mortality and the time reference of orphanhood estimates may be responsible for the general trend of β with age shown in Table 18.

For the sake of completeness, it should be noted that the 1972 survey included an additional question related to orphanhood that was intended to identify those respondents who were the eldest surviving child of their mothers, with a view to removing the possible bias arising from multiple reporting of the same mother. An analysis of these data resulted in higher estimates of female mortality (Hill et al., 1977). However, the proportion of all respondents who claimed to be eldest surviving children was higher than would be expected, and the inclusion of other survival orders would tend to bias upwards mortality estimates based on such data. Experience elsewhere with similar questions has tended to confirm their unreliability, so no further use of these data is made in this study.

Adult Male Mortality

Attempts have been made to estimate adult male mortality from information on survival of fathers, but all the possible objections concerning the maternal orphanhood procedure, such as its reliance on models and vague time reference period, apply even more strongly to paternal orphanhood. As an alternative, a procedure based on the survival of a first husband has been developed (Hill and Trussell, 1977) to estimate adult male mortality. In this case, exposure to risk begins at the first marriage of the respondent and is equal to the time since this first marriage took place; in practice, since data are generally tabulated by age, the average exposure to risk is estimated from age using an estimate of average female age at first marriage. Survivorship probabilities for males from age 20 are estimated from proportions of female respondents with a surviving first husband, using regression equations obtained from model cases and using as additional independent variables the singulate mean age at marriage of males (locating the approximate starting point of exposure) and of females (providing in conjunction with age the average length of the exposure period).

The 1972 retrospective survey collected information on survival of first husband. Table 19 shows the proportions of women with surviving first husband, and the estimated male survivorship probabilities obtained from them, by age group of women. Once again, using the logit life table system described above, it is possible to estimate the parameters α and β of a logit system, using as the standard a Coale-Demeny "North" level 16 male model life table, for each adult male survivorship probability in combination with a male probability of survival to age 2, $l(2)$. The values of α and β for each estimate are shown in Table 19 and make it possible to compare

estimates of adult survivorship obtained from orphanhood with those obtained from widowhood. The estimated life table constants show considerable variation from one age group to another, though the overall range is somewhat narrower than in the case of orphanhood, and the estimates show no clearly marked trend. The average values of the constants, however, are very similar to those obtained from orphanhood, the mean values of β being 0.91 from widowhood and 0.89 from orphanhood and the mean values of α being 0.094 and 0.080, respectively. It is no surprise that the estimates of α should match, since they are largely determined by the assumed values of $l(2)$ by sex; in this case, the split by sex was adopted from the "North" family of model life tables. The close agreement of the mortality pattern variable, β, however, is an encouraging indication of consistency in the data. Of course, if the age patterns of mortality for males and females were not related in a way similar to that of the standards being used, the values of β obtained from orphanhood and widowhood would not be expected to be the same.

Male and female life tables can be constructed using the logit system, after developing estimates of α and β for a particular standard. The combination of adult and child mortality estimation procedures provides the required estimates, and male and female life tables have been constructed using "North" level 16 model life tables as standards. For both sexes, β was taken as 0.90, and α was taken as 0.061 for females and 0.069 for males; these latter values were obtained from the mortality levels estimated for a period five years before the 1974 census, given the trends shown in Figure 6. Table 20 shows abridged life tables obtained from the use of the logit system; it also shows, for purposes of comparison, the age-specific mortality rates obtained by cumulating intercensal deaths for 1961–1973, inflated to allow for estimated underregistration, and dividing by estimated exposure to risk, obtained from adjusted census age distributions. Male deaths were inflated by 1.20, female deaths by 1.32; the 1961 census population was adjusted by a factor of 0.9912, to move the population back to the beginning of the year; the 1974 population was adjusted up by a factor of 1.1017, this being an adjustment of 1.11 for underenumeration and of 0.9925 to move the population back to the beginning of the year.

The comparison of the two columns of age-specific mortality rates in Table 20 is interesting. For males, the registered rates are lower than those of the life table obtained by indirect techniques up to age 25 and over age 70, but from ages 25 to 70 the agreement is remarkable. For females, the registered rates are below those from the life table up to age 30, somewhat above them from ages 30 to 70, and somewhat below them over age 70. In general, however, the age-specific mortality rates from the two sources,

TABLE 20 Abridged Life Table Obtained from Indirect Techniques: Honduras

x	l_x	L_x	${}_nq_x$	${}_nm_x$	Adjusted Death Registration ${}_nm_x$ 1961-1973[a]
Males					
0	10,000	9,165	.1246	.13599	.02328 (.04291)[b]
1	8,754	33,579	.0671	.01750	
5	8,166	40,235	.0291	.00591	.00440
10	7,928	39,322	.0161	.00325	.00216
15	7,800	38,592	.0210	.00425	.00301
20	7,636	37,616	.0296	.00601	.00498
25	7,410	36,487	.0304	.00618	.00621
30	7,185	35,347	.0321	.00652	.00670
35	6,954	34,152	.0356	.00725	.00727
40	6,707	32,822	.0424	.00866	.00868
45	6,422	31,288	.0512	.01052	.00983
50	6,093	29,435	.0677	.01401	.01321
55	5,681	27,175	.0865	.01809	.01941
60	5,189	24,366	.1218	.02593	.02584
65	4,557	20,807	.1737	.03805	.04117
70	3,766	16,450	.2525	.05780	.08713 (.10269)[b]
75	2,815	11,531	.3613	.08818	
80	1,798	8,691	1.0000	.20687	
e_0	50.71				
e_{10}	53.49				
Females					
0	10,000	9,314	.1055	.11327	.02362 (.03695)[b]
1	8,945	34,417	.0627	.01630	
5	8,384	41,370	.0262	.00532	.00478
10	8,164	40,508	.0153	.00309	.00207
15	8,039	39,843	.0175	.00354	.00275
20	7,898	39,073	.0211	.00427	.00328
25	7,731	38,188	.0242	.00490	.00433
30	7,544	37,205	.0273	.00554	.00570
35	7,338	36,125	.0308	.00626	.00639
40	7,112	34,920	.0360	.00733	.00811
45	6,856	33,588	.0404	.00825	.00912
50	6,579	32,033	.0524	.01077	.01221
55	6,234	30,095	.0690	.01429	.01847
60	5,804	27,565	.1003	.02111	.02690
65	5,222	24,143	.1507	.03260	.04346
70	4,435	19,678	.2253	.05077	.08885 (.09640)[b]
75	3,436	14,370	.3271	.07822	
80	2,312	11,958	1.0000	.19334	
e_0	54.44				
e_{10}	56.26				

Note: standard is "North" level 16; $\alpha = 0.061$; $\beta = 0.90$.

[a] See text for method of adjustment.

[b] Comparable grouped value from life table.

which are effectively completely independent, are rather similar, the most marked deviations occurring where they would be expected, at the beginning and at the end of the age range, at which extremes the registration data are most suspect. The results of the indirect techniques, and the adjustments made both to numbers of people and to numbers of deaths for underenumeration and underregistration, respectively, are mutually supported by the close similarity of the mortality rates obtained.

ESTIMATES OF FERTILITY AND MORTALITY FROM A MULTIROUND SURVEY

Between 1970 and 1972, a four-round follow-up sample survey of Honduras was conducted by the Statistics and Census Office of Honduras in collaboration with the Latin American Demographic Centre (CELADE). Changes in the sample population that occurred between rounds, as a result of births, deaths, or movements in or out of the sample areas, were recorded. Conventional rates were then calculated using the observed events as numerators and person-years lived by relevant population subgroups as denominators. Total exposure of the whole sample slightly exceeded 51,000 person-years.

TABLE 21 Fertility Estimates from Multiround Survey, 1971-1972, with Comparable Estimates from Other Sources: Honduras

	Age-Specific Fertility Rates		
	Multiround Survey 1971-1972[a]	Adjusted Registration 1971[b]	Retrospective Survey 1972
Age group of women			
15-19	.1707	.1695	.1833
20-24	.3165	.3148	.3162
25-29	.3392	.3298	.3309
30-34	.3070	.2896	.2924
35-39	.2213	.2244	.2260
40-44	.1267	.1071	.1180
45-49	.0177	.0272	.0204
Total fertility	7.50	7.31	7.44
Mean age of childbearing	29.3	29.3	29.2

[a] Camisa (1975).

[b] Registered births inflated by 1.18, estimated female population allowing for underenumeration in 1974.

FIGURE 7 Estimated age-specific fertility rates from selected sources, 1971 and 1972: Honduras.

Table 21 shows age-specific fertility rates, total fertility, and the mean age at childbearing for the period covered by the survey, roughly the whole of 1971 and the first half of 1972, together with rates based on adjusted birth registration data for 1971 and on the results of the retrospective survey for 1972. Figure 7 graphically shows the rates by sources. The age-specific rates, total fertility rates, and mean ages of the fertility schedule are all very similar, and the multiround survey results confirm an estimate of total fertility in the 7.3–7.5 range for 1971 and 1972. A detailed analysis of the fertility data from the multiround survey is provided by Camisa (1975).

Age-specific mortality rates by sex have also been calculated from the survey results, and life tables have been constructed from them (Ortega and Rincon, 1975). When comparing age-specific rates with those from other sources, it must be remembered that the results are affected by small numbers of events in many cells, as few as four or five deaths being recorded for several sex and age-specific categories. Certain adjustments

TABLE 22 Age-Specific Mortality Rates, Observed and Adjusted, from Multiround Survey, 1971-1972, with Comparable Rates from Indirect Estimation Procedures: Honduras

Age Group	Males			Females		
	Multiround Survey		Retrospective Survey	Multiround Survey		Retrospective Survey
	Observed	Adjusted[a]		Observed	Adjusted[a]	
0-4	.05496	.05007	.04291	.03717	.03458	.03695
5-9	.00433	.00486	.00591	.00405	.00470	.00532
10-14	.00254	.00225	.00325	.00349	.00215	.00309
15-19	.00184	.00285	.00425	.00302	.00275	.00354
20-24	.00263	.00376	.00601	.00291	.00345	.00427
25-29	.00699	.00471	.00618	.00420	.00430	.00490
30-34	.00341	.00543	.00652	.00515	.00500	.00554
35-39	.00663	.00631	.00725	.00617	.00590	.00626
40-44	.00516	.00813	.00866	.00387	.00730	.00733
45-49	.00626	.01084	.01052	.01062	.00960	.00825
50-54	.01379	.01458	.01401	.01675	.01280	.01077
55-59	.02431	.02016	.01809	.00894	.01750	.01429
60-64	.02670	.02804	.02593	.02393	.02500	.02111
65-69	.01509	.04026	.03805	.03575	.03700	.03260
70-74	.03917	.05711	.05780	.04972	.05300	.05077
75+	.12158	.11630	.13920	.06169	.11522	.13051
e_0	—	50.91	50.71	—	55.53	54.44
e_{10}	—	55.41	53.49	—	56.68	56.26
${}_5q_0$	—	.2079	.1834	—	.1521	.1616

[a] Ortega and Rincon (1975).

were made to the mortality rates before calculating the life tables: to move the minimum mortality rate from the 15–19 age group to the 10–14 age group; to smooth the rates from age 5 to age 50; and to increase somewhat the observed mortality rates over age 50. Table 22 shows the mortality rates by sex and five-year age group both before and after smoothing; also shown are the rates obtained from the life tables constucted from indirect estimation procedures. Overall, the agreement between the two life tables, in terms of expectation of life at birth, is very close, but the details are rather different. For both sexes, adjusted rates from the multiround survey indicate lower mortality from age 5 to age 45 and rather lower mortality above age 75. Under age 5, male mortality from the multiround survey exceeds that from the life table based on the indirect methods, while female mortality from the multiround survey is below that from the indirect life table. The systematic nature of these differences arises largely from the smoothing applied to the multiround survey rates; the unsmoothed rates show substantial fluctuations, though after age 40 the fluctuations are around the rates obtained from the indirect methods. However, the deficit of deaths in the multiround survey between age 5 and age 40 relative to the deaths expected on the basis of the indirect life tables remains.

It is possible to check the completeness of the death recording of the multiround survey by applying both the Brass and the Preston method outlined in the section on vital registration. Results of these methods (obtained in the same way as described above) are shown in Table 23. As before, the estimates vary considerably, those obtained from the Preston method depending critically on the rate of growth used. However, the

TABLE 23 Estimates of Completeness of Death Recording by Sex, 1971-1972 Multiround Survey: Honduras

	Males		Females	
Method	Completeness	Rate of Growth	Completeness	Rate of Growth
Brass	0.912	3.2	0.763	2.9
Preston[a]	0.989	(3.4)	0.915	(3.5)
Preston[b]	0.908	(3.2)	0.718	(2.9)

[a] Based on intercensal growth rate, 1961-1974, after adjusting the 1974 population for an estimated undercount of 10 percent.

[b] Based on growth rate obtained from Brass method.

TABLE 24 Comparison of Age-Specific Mortality Rates Under Age 10 from the Multiround Survey with Model Values: Honduras

		Age-Specific Mortality Rates ($_nm_x$)			Relative Deviation from Model	
x	n	Survey	"North" Level 15	"South" Level 15	"North"	"South"
Males						
0	1	.15773	.10803	.13616	.4601	.1584
1	1	.03884	.02785	.04133	.3946	−.0602
2	1	.02527	.01732	.01966	.4590	.2854
3	1	.01383	.01307	.01070	.0581	.2925
4	1	.00441	.01005	.00596	−.5612	−.2601
5	5	.00433	.00593	.00329	−.2698	.3161
Females						
0	1	.09904	.08984	.12096	.1024	−.1812
1	1	.03386	.02506	.04042	.3512	−.1623
2	1	.01844	.01620	.01917	.1383	−.0381
3	1	.01176	.01259	.01027	−.0659	.1451
4	1	.00550	.00985	.00589	−.4416	−.0662
5	5	.00405	.00543	.00316	−.2541	.2816

evidence suggests that male deaths were more completely recorded than female deaths, but that both sexes suffered some omission. The comparisons in Table 22 suggest that female deaths were differentially omitted only over age 75 and lend little support to the large differences in completeness shown in Table 23. The adjusted female mortality rates from the multiround survey agree very closely with the mortality rates shown in Table 20 obtained by inflating intercensal registered deaths by a factor of 1.32 and do not agree well with the rates from the life table based on indirect techniques. For male mortality, however, the mortality rates based on adjusted intercensal registered deaths agree with those from the indirectly obtained life table, and neither set agrees closely with the rates from the multiround survey. The differences, of course, are of the age pattern of mortality rather than of the overall level, as is clear from the similarity of the expectations of life at birth in Table 22.

A further element of confusion is introduced by the age pattern of mortality from the multiround survey. Deaths and person-years lived are classified by single years of age up to age 5, and the age pattern of child mortality can therefore be compared with models in great detail. Unfortunately, such a comparison suggests that the "South" family is more satisfactory than the "North," as shown in Table 24, though it should be noted that over age 5, "North" is more satisfactory than "South." Neither family is very satisfactory, of course, but the "North" pattern results in a definite trend of relative deviations with age, while the "South" pattern gives a fairly random scatter. With mortality rates from the vital registration system and lacking any breakdown under age 5, the "North" family provided easily the best fit taking all ages into account, and the "South" family provided the worst fit. The most likely conclusion may be that the age pattern of mortality up to age 5 is not well represented by the "North" mortality pattern, though it provides the best available approximation thereafter.

Glossary

AGE HEAPING A tendency for enumerators or respondents to report certain ages instead of others; also called age preference or digit preference. Preference for ages ending in 0 or 5 is widespread.

AGE PATTERN OF FERTILITY The relative distribution of a set of *age-specific fertility rates*. It expresses the relative contribution of each age group to *total fertility*.

AGE-SPECIFIC FERTILITY RATE The number of births occurring during a specified period to women of a specified age or age group, divided by the number of person-years-lived during that period by women of that age or age group. When an age-specific fertility rate is calculated for a calendar year, the number of births to women of the specified age is usually divided by the midyear population of women of that age.

AGE-SPECIFIC MORTALITY RATE The number of deaths occurring during a specified period to persons (usually specified by sex) of a specified age or age group, divided by the number of person-years-lived during that period by the persons of that age or age group. When an age-specific mortality rate is calculated for a calendar year, the number of deaths to persons of the specified age is usually divided by the midyear population of persons of that age.

AGE STANDARDIZATION A procedure of adjustment of crude rates (birth, death, or other rates) designed to reduce the effect of differences in age structure when comparing rates for different populations.

BIRTH HISTORY A report of the number and dates of all live births experienced by a particular woman; see also *pregnancy history*. The sex of each child, the survival of each child to the date of the interview and, where pertinent, the date of death are also generally recorded.

BIRTH ORDER The ordinal number of a given live birth in relation to all previous live births of the same woman (e.g., 5 is the birth order of the fifth live birth occurring to the same woman).

BIRTH RATE See *crude birth rate*.

CHILDBEARING AGES The span within which women are capable f bearing children, generally taken to be from age 15 to age 49 or, sometimes, to age 44.

CHILDREN EVER BORN(E) The number of children ever borne alive by a particular woman; synonymous with *parity*. In demographic usage, stillbirths are specifically excluded.

COHORT A group of individuals who experienced the same class of events in the same period. Thus an age cohort is a group of people born during a particular period, and a marriage cohort is a group of people who married during a particular period. The effects of a given set of mortality or fertility rates are often illustrated by applying them to hypothetical cohorts.

COHORT FERTILITY The fertility experienced over time by a group of women or men who form a birth or a marriage cohort. The analysis of cohort fertility is contrasted with that of *period fertility*.

CRUDE BIRTH RATE The number of births in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as births per thousand population. The crude birth rate for a single year is usually calculated as the number of births during the year divided by the midyear population.

CRUDE DEATH RATE The number of deaths in a population during a specified period divided by the number of person-years-lived by the population during the same period. It is frequently expressed as deaths per thousand population. The crude death rate for a single year is usually calculated as the number of deaths during the year divided by the midyear population.

CUMULATED FERTILITY An estimate of the average number of children ever borne by women of some age x, obtained by cumulating *age-specific fertility rates* up to age x; also often calculated for age groups.

DEATH RATE See *crude death rate*.

EXPECTATION OF LIFE AT BIRTH The average number of years that a member of a *cohort* of births would be expected to live if the cohort were subject to the mortality conditions expressed by a particular set of *age-specific mortality rates*.

FERTILITY HISTORY Either a *birth history* or a *pregnancy history*.

FORWARD SURVIVAL A procedure for estimating the age distribution at some later date by projecting forward an observed age distribution. The procedure uses *survival ratios*, often obtained from model *life tables*. The procedure is basically a form of population projection without the introduction of new entrants (births) to the population.

GENERAL FERTILITY RATE The ratio of the number of live births in a period to the number of person-years-lived by women of *childbearing ages* during the period. The general fertility rate for a year is usually calculated as the number of births divided by the number of women of childbearing ages at midyear.

GROSS REPRODUCTION RATE The average number of female children a woman would have if she survived to the end of her childbearing years and if, throughout, she were subject to a given set of *age-specific fertility rates* and a given *sex ratio at birth*. This number provides a measure of replacement fertility in the absence of mortality.

GROWTH RATE The increase or decrease of a population in a period divided by the number of person-years-lived by the population during the same period. The increase in a population is the result of a surplus (or deficit) of births over deaths and a surplus (or deficit) of immigrants over emigrants. (The annual increase is often expressed as a fraction of the total population at the beginning of the year, but this convention has the inconvenient characteristic of not being readily defined for a five-year interval and of being unequal to the difference between the birth rate and the death rate even in the absence of migration.) See also *rate of natural increase*.

INFANT MORTALITY RATE The number of deaths of children under 1 year of age occurring in a year per 1,000 live births occurring in the same year; also used in a more rigorous sense to mean the number of deaths that would occur under 1 year of age in a *life table* with a *radix* of 1,000.

LIFE TABLE A listing of the number of survivors at different ages (up to the highest age attained) in a hypothetical cohort subject from birth to a particular set of age-specific mortality rates. The rates are usually those observed in a given population during a particular period of time. The tabulations accompanying a life table include other features of the cohort's experience: its expectation of life at different ages, the probability of surviving from the beginning of each age interval to the end of that interval, etc.

MARITAL FERTILITY Any measure of fertility in which the births (in the numerator) are births to married women and in which the number of person-years-lived (in the denominator) also pertains to married women. In some instances, the designation "married" includes persons in consensual unions.

MEDIAN The value associated with the central member of a set that is ordered by size or some other characteristic expressed in numbers.

MEAN AGE OF CHILDBEARING The average age at which a mortality-free *cohort* of women bear their children according to a set of *age-specific fertility rates*.

MEAN AGE OF CHILDBEARING IN THE POPULATION The average age of the mothers of the children born in a population during a year. This measure incorporates the effects of both mortality and the age distribution.

MODEL LIFE TABLE An expression of typical mortality experience derived from a group of observed *life tables*.

MOVING AVERAGES The successive averaging of two or more adjacent values of a series in order to remove sharp fluctuations.

NATURAL FERTILITY The age pattern of *marital fertility* observed in non-contraceptive populations where reproductive behavior is not affected by the number of children already born.

NET MIGRATION The difference between gross immigration and gross emigration.

NET REPRODUCTION RATE The average number of female children born per woman in a *cohort* subject to a given set of *age-specific fertility rates*, a given set of age-specific mortality rates, and a given *sex ratio at birth*. This rate measures replacement fertility under given conditions of fertility and mortality: it is the ratio of daughters to mothers assuming continuation of the specified conditions of fertility and mortality.

OWN-CHILDREN METHOD A refinement of the *reverse survival* procedure for fertility estimation, whereby estimates of *age-specific fertility rates* for the recent past are obtained by relating mothers to their own children, using information on relationship and other characteristics available from a census or survey.

PARITY See *children ever born*.

PERIOD FERTILITY The fertility experienced during a particular period of time by women from all relevant birth or marriage *cohorts*; see also *cohort fertility*.

PREGNANCY HISTORY A report of the number and the dates of occurrence of all the pregnancies experienced by a particular woman. The outcome of the pregnancy—live birth, stillbirth, fetal death—is also recorded.

${}_xq_0$ The probability of dying between birth and some exact age x, sometimes also written $q(x)$: q is the probability of dying, 0 is birth, and x is the exact age up to which the probability of dying refers.

RADIX The hypothetical birth cohort of a *life table*. Common values are 1, 1,000, and 100,000.

RATE OF NATURAL INCREASE The difference between the births and deaths occurring during a given period divided by the number of person-years-lived by the population during the same period. This rate, which specifically excludes changes resulting from migration, is the difference between the *crude birth rate* and the *crude death rate*.

RETROSPECTIVE SURVEY A survey that obtains information about demographic events that occurred in a given past period, generally terminating at the time of the survey.

REVERSE SURVIVAL A technique to estimate an earlier population from an observed population, allowing for those members of the population who would have died according to observed or assumed mortality conditions. It is used as a method of estimating fertility by calculating from the observed number of survivors of a given age a the expected number of births that occurred a years earlier. (In situations for which mortality is known or can be reliably estimated, reverse survival can be used to estimate migration.)

ROBUSTNESS A characteristic of estimates that are not greatly affected by deviations from the assumptions on which the estimation procedure is based.

SEX RATIO AT BIRTH The number of male births for each female birth, or male births per 100 female births.

SINGULATE MEAN AGE AT MARRIAGE (SMAM) A measure of the mean age at first marriage, derived from a set of proportions of people single at different ages or in different age groups, usually calculated separately for males and females.

SURVIVAL RATIO The probability of dying between one age and another; often computed for age groups, in which case the ratios correspond to those of the person-years-lived function, ${}_nL_x$, of a *life table*.

SYNTHETIC PARITY The average parity calculated for a hypothetical cohort exposed indefinitely to a set of period *age-specific fertility rates*.

TOTAL FERTILITY RATE (TFR) The average number of children that would be born per woman if all women lived to the end of their childbearing years and bore children according to a given set of *age-specific fertility rates*; also referred to as total fertility. It is frequently used to compute the consequence of childbearing at the rates currently observed.

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